ELECTRICAL ENGINEERING

Registered United States Patent Office

The Cover: One of several 100,000-kva 330,000-volt power transformers is shown at the Pittsfield, Mass., plant of the General Electric Company. Equipped with load-tap-changing mechanisms, these units are being installed by the Atomic Energy Commission at the step-down end of the Ohio Valley Electric Company's new 330-kv transmission line.

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Every foot of Okolite-Okoprene is subjected to the highest voltage a-c and d-c water-immersed factory acceptance tests in the industry.

why Okonite cables last longer

Field service is the only true test of a cable's worth. And one case history after another shows that Okonite cables have given years of outage-free operation under the most difficult conditions. Premium materials and careful manufacturing methods have helped build this record. But materials and methods alone do not make dependable cable. Built into every Okonite construction are two all-important extras: research and quality control.

Take quality control. One man out of every six at Okonite is engaged in testing. During each phase of production, Okolite-Okoprene cables are inspected and tested to make certain they meet Okonite's standards. The following list of quality controls are not generally used by other cable manufacturers, but are *always* used at Okonite. Many of these controls are distinctive Okonite developments.

1. The use of the strip-insulating process, which applies a series of insulating strips of controlled thickness, insures a uniform wall of insulation and sheath.
2. Every foot of cable is subjected to the highest voltage a-c and d-c water-immersed factory acceptance tests in the industry.
3. Each batch of insulating and sheathing compound must meet a series of tests before it is applied to the conductor.
4. Foot-by-foot electrical testing and inspection of the insulation and sheath is carried on both before and during application to the conductor.
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HIGHLIGHTS.....

Let's Plan Ahead. In his address at the recent Southern District Meeting, President Monteith called for the co-operation of the membership in serving the AIEE by planning ahead. This means participation both in the Institute's long-range development projects, and on an individual level in one's own professional life (*pp. 457–8*).

Technical Development of the International Broadcasting System of the Voice of America. The major problems confronting international broadcasting from the United States are overcoming the deteriorating effects encountered on the transmission paths through or near the northern auroral zone, the vast distances to certain target areas and reaching them with a strong signal on the popular local broadcast bands, and Communist jamming (*pp. 459–64*).

Magnetic-Memory Device for Business Machines. The large storage capacity of this memory makes its use economically possible for many data-handling systems where the conventional magnetic drum would be uneconomical. This endless-tape unit offers the access-time advantage of a magnetic drum with the storage-capacity feature of a tape recorder (*pp. 466–8*).

Hungarian Wartime Telecommunication Experience. These data on preparation for and actual experience during various phases of the war as it affected telecommunications are presented to help in the visualization of the technical problems and conditions which arise in a war-ravaged country (*pp. 476–80*).

Methods of By-Passing Substation Equipment. Auxiliary equipment in substations permits removal of a component item from service for maintenance purposes, service to be restored more quickly after failure of the component, and an added sense of security. A number of accepted schemes for by-passing substation equipment is presented (*pp. 470–5*).

Human Resources in the Technological Future. The technological future, without doubt, is a bright one, but it presents a special challenge to the electrical engineering profession. Part of that challenge is the need for technically trained manpower, which will be greater than ever before (*pp. 482–5*).

A Versatile High-Voltage D-C Insulation Tester. Nondestructive d-c tests used to measure insulation deterioration on high-voltage apparatus reveal faults not observable by a-c test, and give warning of equipment failures before the danger point is reached. The described high-voltage insulation resistance meter provides a convenient means for making such d-c over-potential tests (*pp. 486–8*).

Audio Amplifier Distortion Analysis and Measurement. Basic methods to recognize, measure, and reduce unwanted distortion in the electronic amplifiers of audio systems are treated. Tube linearity, circuit reactances, and random interference are subdivided into six undesirable manifestations and each is discussed (*pp. 490–5*).

A Time-Delay Device Using Transistors. High-accuracy static time-delay circuitry designed to yield quite long time delays with extreme accuracy makes use of junction transistors in conjunction with rectangular-hysteresis-loop magnetic cores. Such a design permits operation under adverse conditions (*pp. 498–501*).

Basic Circuitry for Pipe-Line Pump Stations Under Remote Control. This article presents basic circuitry for electrically powered pipe-line pumping stations employing sequence control for the pump units which are, therefore, suitable for remote operation (*pp. 504–09*).

Gamma Radiation Effects on Liquid Dielectrics. The tests made indicate that an appreciable transformation is effected by gamma radiation either by converting the dielectric liquids into solids or decomposing them into acids and gases. Certain additives apparently can increase the stability of dielectric liquids subjected to gamma fields (*pp. 510–15*).

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Bimonthly Publications

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Noise Reduction in Large Rotating Machines. This article discusses a method of reducing noise in large rotating machines, and in particular electric machines, by the use of sound-absorbing materials. This added advantage is possible with very moderate additional expense (*pp. 515–17*).

Some Electrical and Thermal Characteristics of Helium and Sulfur-Hexafluoride Mixtures. The results are presented of a study of some of the electrical and thermal properties of these mixtures as compared with the pure gases: air, hydrogen, helium, and sulfur-hexafluoride. It is shown that the addition of relatively small amounts of sulfur-hexafluoride to helium will result in an electrical strength greater than that of air and of hydrogen; the thermal properties of such mixtures are nearly as good as hydrogen (*pp. 520–3*)

Board of Directors' Meetings. St. Petersburg, Fla., was the scene of two recent meetings of the AIEE Board of Directors. A special meeting was held on April 13 to consider a report concerning a new location for the Engineering Societies Building. The regular spring meeting was held on the following day (*pp. 532–3*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

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Now 150 kva on Single Pole. You can hang three L-M light 50 kva obround transformers on a single-pole structure, obtaining 33⅓% more capacity and 15% less bending moment on the pole than with three 37½ kva round tank design transformers.

How L-M Obround Design Provides Additional Capacity On Structures

New obround tank design is smaller, lighter, has shorter moment arm, retaining all outstanding Round-Wound® performance characteristics.

By **ALVIN B. COYLE**
Manager
Transformer Sales
Line Material Company

Now you can hang transformers of larger capacity on a pole structure with L-M's lighter, smaller obround transformer tank design. The additional capacity is obtained without changing outstanding performance characteristics of L-M's Round-Wound design.

Less Weight

The obround design provides a smaller tank with less transformer oil, resulting in a lighter, easier-to-handle transformer. Cooling tubes are installed where necessary to provide the cooling surface for maintaining the same low hot-spot and top oil temperature-performance characteristics found in all other L-M transformers. In addition, the transformer's repetitive overload capacity is improved as the result of the faster transfer of heat from the coils to the cooling air.

Shorter Moment Arm

L-M's new obround design brings the center of gravity closer to the pole, which reduces the moment arm distance from the pole. The combination of lighter weight and less moment arm distance substantially decreases the total bending moment on the pole and crossarms, and thus greatly increases the potential capacity of all your transformer structures.

You can take advantage of savings such as these:

Larger transformers can be hung closer to the top of the pole, eliminating the need for a higher pole and additional spacing.

Single-pole, three-phase transformer structures can now serve more load with the additional transformer capacity available. New 50 kva obround transformers have less bending moment on the pole and on crossarms than previous 37½ kva round tank design. Here L-M's light obround transformers may eliminate the need for costly two-pole structures.

Pole-Mounted 167 kva Transformers

L-M's light-weight 167 kva transformer can be pole-mounted; provides a full 167 kva of capacity on a single-pole structure. And it, too, provides L-M's well-known overload capacity.

To serve three-phase loads you can hang three L-M light 167 kva transformers or 500 kva on a two-pole structure, eliminate expensive platforms, ground pads, or vaults in many instances, and make further use of existing facilities.

L-M's light, obround design transformers are available in single-phase 5 kva through 167 kva in each standard distribution voltage class.

Get Details On Lighter-Weight Obround Transformers

Ask the L-M Field Engineer for application information, weights and dimensions on L-M obround transformers and the exclusive Round-Wound design. Or write Mr. Coyle at Line Material Company, Transformer Division, Zanesville, Ohio (a McGraw Electric Company Division).

219-A

LINE MATERIAL *Transformers*

Let's Do More Planning Ahead

A. C. MONTEITH
PRESIDENT AIEE

A calculated financial schedule, scientific membership opinion surveys, a study of Institute structure by experts, continued work towards a unity organization—these are but four of the over-all preplanned projects which are being undertaken to insure the future of the AIEE.

PROBABLY the greatest help we can give the Institute today is to take time in all of our AIEE work to do more planning ahead—both for the long pull and for the short haul.

The Board of Directors reached this same conclusion many months ago, especially in terms of long-range planning. As a result of taking time to plan, a number of preplanned projects of over-all long-range significance are being carried forward to safeguard and strengthen the future of the Institute as it continues to increase in size and complexity.

SOME OVER-ALL PREPLANNED PROJECTS

FOUR of these over-all projects may be of especial interest at this time.

The first one hits the pocketbook; it is painful, but necessary—increased dues. At the Winter General Meeting in New York, the Board of Directors voted to increase future annual dues $5.00 for all AIEE members, except students. The facts about the dues problem have been published (see *EE, Apr '55, p 273*), so it is not necessary to go into details here. However, it should be pointed out that the Institute is about $100,000 in the red, as compared to $82,000 in the black 2 years ago. Members have been receiving about $25 worth of services for $12 average annual dues, and most are paying the same dues as charged a half-century ago. A calculated preplanned financial schedule enabled the Board to stave off increasing dues until this late date—long after all comparable technical societies had raised their dues. This action by the Board protects our investment in our Institute. The bills for the 1955–56 dues have been mailed. Your prompt reply is a vote of confidence in our Institute.

A second preplanned long-range project is to find out what Institute members are thinking about and what you really want the Institute to do for you. A feeler in this direction was the questionnaire on employment conditions, which 25,000 members returned, and on which 7,000 took time to jot down individual comments. The interesting results were published in the February 1955 issue of *Electrical Engineering* (*pp 96-7*). Highlights included the facts that: (1) we are a fairly young group of engineers (57 per cent of us are under 40 years old); (2) three out of four of us work in industry; and (3) about 70 per cent of us believe that our kind of work is incompatible with unionization.

With this successful self-sponsored questionnaire behind us, we are now preparing to carry out a scientific member-opinion survey. This will give us an idea of what our members are looking for. We know that the opinions and desires of our members are shifting. Their interests are affected by the times and economic conditions, and we should follow their interests. This scientific survey is about ready to be launched. It will be based on a proved personal interview technique. This insures obtaining pro-

Essentially full text of an address presented at the general session of the AIEE Southern District Meeting, St. Petersburg, Fla., April 13–15, 1955.

A. C. Monteith is with the Westinghouse Electric Corporation, Pittsburgh, Pa.

portionate views from members who usually will not respond to a mailed questionnaire.

A third piece of planning is the authorization by the Board for a complete study of Institute structure by outside specialists. Preliminary work on this study is now under way. Members of the staff of a nationally known firm of consultants already are attending meetings of Sections, technical groups, and Section executive committees to become better acquainted with these areas of the Institute. The real work of the organizational study starts with the results of the membership opinion survey. That survey will tell us what the members want; the organizational study project will tell us how to accomplish it.

A fourth over-all major project going forward on a planned approach is our consistent effort to work towards a unity organization with a much broader base than now accomplished. Either we must have a unity organization that will undertake the professional phase of the work that is common to all engineering branches, or we must organize to accomplish it in our own structure. The organization the AIEE Board of Directors feels necessary, and on which they feel they have a mandate from the membership, must accomplish two things. One, it must tie the technical societies together in broad technical matters—such as in the field of nucleonics or the like. Two, it must speak for the engineering profession on broad matters such as manpower, the promotion of engineering education, unionization of engineers, or professional development. Some sister societies feel that the Engineers Joint Council (EJC), a federation of societies, should and does fill this need.

At present, a new plan is being studied. It would consist of two autonomous branches: one professional in nature and one technical in nature. Each branch would select representation to an overriding board of directors that could be called "The American Engineering Association." The professional branch would be made up of individual members with right of vote and determination and it would provide means for adequate financing. The technical branch would be similarly organized. Membership would be common in the two branches.

Your representatives are still pressing for a plan of evolution of EJC that would give it greater stature in providing for more active participation in the professional phases stemming from the grass roots. We will keep you advised from time to time on our progress, or the lack of it, as it may be necessary to review this matter with you to evolve a final plan acceptable to you.

Of course there are many other general activities in AIEE where advance planning is proving valuable, for example: (1) clarification of long-range objectives of the Institute in its Standards work; (2) re-evaluation of membership requirements; (3) scheduling of General and District meetings 5 years ahead and correlation with other major societies to avoid serious conflicts in dates; and (4) launching of a continuing effort to attract new major honors and awards.

COMMITTEE AND SUBCOMMITTEE PLANNING

In addition to the planning that is going into these broad general projects, the Institute has as much to gain, and perhaps even more in the long run, if more planning were done by the committees and subcommittees. Often, here is especially where the members can help. Many of you are members of some Institute committee. If you are a committee officer you have a major opportunity to make sure that your committee is planning ahead. If you are a member, you can directly influence your group by pointing out where you think more planning would be of help.

As we all know from our engineering work, planning is the key to successful venture. Of course, the first step is to make sure the committee has its full complement of officers, at least a chairman, vice-chairman, and secretary. These should be men on whom the Institute can build for natural development for promotion to higher offices. This does not necessarily mean formalized, preset succession, but planning ahead by the committee to have ripe leadership available when it is needed.

If we could get all our committees operating smoothly on such a system, there might even be the possibility of each chairman having to serve only a single year, like the Institute's President. Think what that would mean. Not only would it substantially lighten the load on each chairman, but, most important, it would give twice as many persons the tempering experience of serving as chairman. This would be the best education we could give our members. Twice as many of you would understand the problem of setting up sessions, the necessity of meeting deadlines for closing dates, etc. There is much more that could be said, but this one example indicates the type of benefit that can be obtained only by planning and organizing for the years ahead.

More advance planning is equally rewarding in working out routine committee operations. For example, committee meetings should be held only after an agenda has been issued several weeks in advance and the topics merit the time and expense involved. Again, for routine or emergency matters that occur between main meetings, see to it that the committee has an executive committee setup to handle them.

PLANNING BY INDIVIDUAL MEMBERS

Even if you are not a member of the Board or a committee officer or a committee member this year, you still have an opportunity to serve the Institute by planning ahead. For instance, plan things now so you can take a more active part in Institute affairs; beat deadlines for any papers you are writing by a few days instead of just getting under the wire; reply to Institute correspondence promptly; and pay your dues on the same day you receive your bill.

Today, the Institute is "big business," and it will probably be twice as big in a few years. We must plan now for tomorrow. Whether you are on the Board of Directors, a national committee, a local committee, or an individual member, I urge you to work for more and better planning in all areas of AIEE. This is an opportunity for a personal contribution that you—and only you—can make. The benefit is twofold. You will add to your own professional development, and you will be doing your part in assuring the future success of the Institute.

Technical Development of the Voice-of-America International Broadcasting System

E. T. MARTIN
MEMBER AIEE

JULIUS ROSS

GEORGE JACOBS
ASSOCIATE MEMBER AIEE

The technical problems confronting the Voice of America, the international broadcasting service of the U. S. Information Agency, and the techniques developed to counteract these obstacles are discussed. Included are such problems as jamming and overcoming the vast distances and deteriorating effects of the northern auroral zone separating the United States from intended audiences.

GORDON DEAN, while chairman of the Atomic Energy Commission, once called that Commission's work "the second most important task in the world." He added: "The first, I think, is somehow or other to pierce the Iron Curtain and let the ordinary Russian know our real and peaceful intentions." As Russia, China, and the satellite countries do not permit the United States to operate information posts in their countries and because of censorship and similar restrictions imposed against newspapers, books, and motion pictures in these countries, radio remains the only medium capable of reaching areas under Communist domination. The U. S. Information Agency therefore operates a world-wide broadcasting system, often referred to as the "Voice of America" (VOA), whose principal task is to reach an audience in areas under Communist domination. The people in these areas constitute the VOA's principal "target audience." The International Broadcasting Service of the U. S. Information Agency, with its announcement "This is the Voice of America," broadcasts in 38 different languages beamed to selected areas of the world. Included in these 38 languages are English, Russian, the languages of the satellite countries and areas occupied by the Soviet Union, the three major dialects of China, as well as the popular languages of Europe, and the Near, Middle, and Far East. Fig. 1 shows the complete global network of VOA broadcasting facilities.

THE PROBLEMS

THE PROBLEMS that confront international broadcasting from the United States can be stated as follows:

1. The problem of overcoming the deteriorating effects encountered on the transmission paths from the United States, passing through or near the northern auroral zone, to the important target areas of Europe and Asia. Fig. 2 shows how the shielding effect of this auroral zone prevents direct transmission from the United States of technically satisfactory short-wave broadcasts to many important areas of the world on the consistent basis necessary to attract and maintain a listening audience.

2. The problem of overcoming the vast distances between the United States and the target area and reaching the listener with a strong signal on the broadcast bands that are popular in this area.

Later in this article an additional problem that has developed since 1948 will also be discussed. This has arisen as a result of Communist jamming of VOA transmissions.

DEVELOPMENT OF THE SYSTEM

OPERATIONAL EXPERIENCE gained during the war years clearly indicated that effective world-wide broadcasting requires a carefully developed integrated network or system of facilities, specifically designed to deliver a strong technically competitive broadcast to a listener in any selected area of the world on either the short-, medium- or long-wave broadcasting bands—whichever are popular in the specific area and lie within range of most of the available receivers.

Long-range forward planning is essential in the development of such a system. It cannot be developed piecemeal, but must take into account all the interrelated elements of the system. In the case of international broadcasting, the system begins at the microphone and ends in the receiver of the listener. In the technical development of the VOA, the "systems concept"—that of considering the performance of the system as a whole—has been of paramount importance.

RELAY BASES

THE DEVELOPMENT of the VOA facilities system centers upon the use of overseas relay bases, at locations where it is possible to take maximum advantage of favorable radio propagation conditions, to overcome the problems facing direct short-wave broadcasting from the United States.

While transmission paths passing through the auroral zones are heavily distorted and absorbed, paths that do not pass near the auroral zones are not affected by this

Condensed text of a conference paper presented before a session of the AIEE Committee on Television and Aural Broadcasting Systems at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954.

E. T. Martin, Julius Ross, and George Jacobs are all with the U. S. Information Agency, Washington, D. C.

phenomenon. In Fig. 2, for example, the circuit from New York to Tangier, North Africa, does not pass near the auroral zones, and it is therefore possible to maintain a reliable program service from the United States to Tangier by short wave.

The effects of the auroral zone on circuits from Tangier are indicated in Fig. 3. It can be seen, by comparison with Fig. 2, that the very areas that are shielded from the United States can be reached without difficulty from Tangier. Therefore, programs transmitted from New York to Tangier can be simultaneously relayed from Tangier directly into the European or Near and Middle Eastern target areas—areas that cannot be reached effectively directly from the United States. By the use of appropriately located relay stations in this manner, the auroral zones can be by-passed, and a technically effective transmission can be delivered to target areas that are normally shielded from direct transmission from the United States.

Auroral zone by-passes to other areas of the world can be achieved by locating relay bases in, for example, Hawaii and the Philippine Islands. Both the fundamental problems of distance and auroral zone absorption can be solved by this relay base concept. By placing relay bases in appropriate locations, short-wave transmissions can be received at the relay bases directly from the United States with the least possible effects from the auroral zone absorption. After receiving the transmission, the signal can be boosted in strength at the relay base and simultaneously relayed directly into a selected target area on the broadcasting bands that are popular in the area and lie within the range of most of the available receivers.

Based upon this concept, VOA relay bases have been established at various appropriate locations throughout the world. Each relay base is a complete self-contained installation with its own diesel power plant, small studio complement, receiving station for program reception, high-power short-, medium-, or long-wave transmitting facilities, and point-to-point radio Teletype communications facilities.

The relay bases are integrated into a single system so that they can be fed programs directly from the United States, or between each other.

The overseas relay system of the VOA consists of the following:

1. *Tangier, North Africa.* This base is designed primarily as the VOA's main gateway to Europe and the Near and Middle East. At the Tangier base, the major facilities consist of ten high-power short-wave transmitters ranging in power from 35 to 100 kw. Twenty-four rhombic antennas are available for beaming programs to Europe and the Near and Middle East. Fig. 4 is an aerial view of the Tangier relay base.

2. *Munich, Germany.* This location is near enough to the Central European target areas so that medium- and long-wave broadcast bands can be used for relaying broadcasts to these areas. The base consists of seven high-power short-wave transmitters ranging in power from 8 to 100 kw and a number of lower power short-wave transmitters. A 300-kw medium-wave transmitter operates on a frequency of 1,196 kc and a 1,000-kw long-wave transmitter operates on a frequency of 173 kc. Twenty short-wave antennas are available for coverage of Europe, the Eurasian areas of the Soviet Union, Near and Middle East, and parts of Africa. The medium-wave antenna is a 4-element array providing four separate patterns each beamed towards a desired European target area. The antenna system is designed for sky-wave radiation out to about 500 miles from Munich. The long-wave antenna consists of a single top-loaded tower over 900 feet high. It has been designed for omnidirectional radiation for Central European coverage.

3. *Salonika, Greece.* This relay base was engineered to take advantage of the nearness to the Balkan target areas. The base consists of four 35-kw short-wave transmitters and a 50-kw medium-wave transmitter operating on a frequency of 791 kc. Ten short-wave antennas are available for coverage of the Balkans, the western Soviet Union, east Europe, and the Near and Middle East. The medium-wave antenna consists of a 2-element directional array providing a reversible cardioid pattern with one beam centered to give sky-wave coverage of the Balkans and the other to give coverage of Greece.

4. *Manila, Philippine Islands.* This base serves as a gateway to Southeast Asia. It consists of three short-wave transmitters ranging in power from $7\frac{1}{2}$ to 50 kw and a 50-kw medium-wave transmitter operating on a frequency of 920 kc. Ten rhombic antennas are available for short-wave coverage of Japan and the Asiatic mainland. The medium-wave antenna system consists of a 6-tower array providing three beams for sky-wave coverage of Southeast Asia and the Philippines.

5. *Honolulu, T.H.* This relay base serves as an auroral by-pass to the Far East and Southeast Asia. It consists of two 100-kw short-wave transmitters and six rhombic antennas beamed on the Far East and Southeast Asia.

6. *San Fernando, Philippine Islands.* This base augments the Manila relay base in coverage of China and Asiatic target areas. One of the newest in the VOA system, it was completed during 1953. The base consists of two 35-kw short-wave transmitters and a 1,000-kw medium-wave transmitter operating on a frequency of 1,140 kc. Again this is one of the world's most powerful medium-wave broadcasting transmitters, being 20 times more powerful than the highest power broadcasting station in use in the United States today. Seven rhombic antennas are used for short-wave coverage of the Orient and Asia as far west as India and Pakistan. The medium-wave antenna system consists of a 4-tower array producing three separate beams directed towards Southeast Asia, China, and the Philippines. The use of this antenna system permits the effective sky-wave radiation of at least 3,500 kw in certain directions. A self-contained diesel-electric plant is capable of generating in excess of 4,500 kw. The diesels operate on the Vapor Phase[1] principle and utilize efficient high-temperature cooling. The diesel equipment has been engineered to operate with either light or heavy fuel oil.

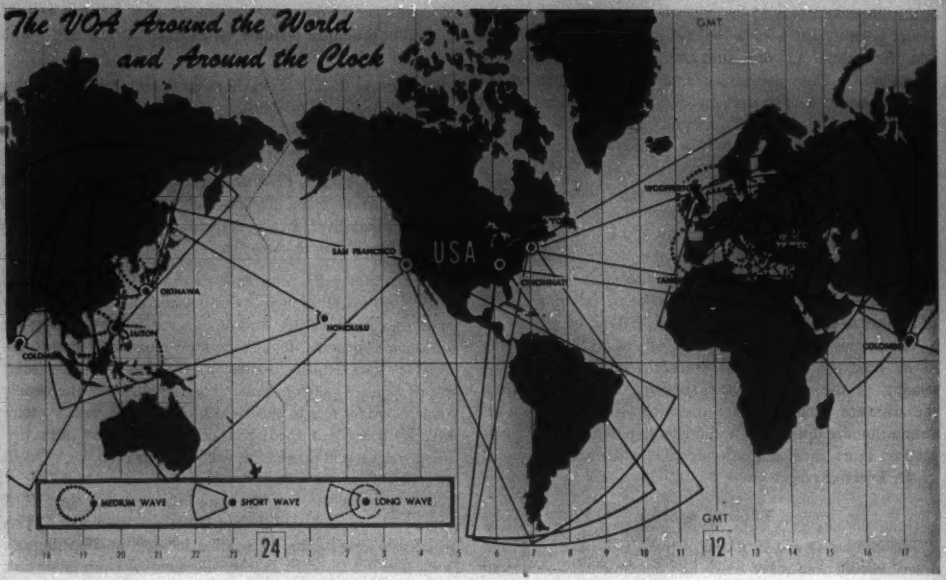

Fig. 1. Global network of the VOA broadcasting facilities, on Mercator's projection, showing how VOA programs are carried to listeners throughout the world. Vertical lines indicate time zones, with Greenwich mean time at 12 noon and the international date line at 24

7. *Okinawa.* This installation is similar to the San Fernando relay base. The San Fernando base is primarily intended to cover the southern and central areas of Asia. The Okinawa base completes the coverage by beaming transmissions towards the central and northern areas of Asia. This plant also consists of two 35-kw short-wave transmitters and a 1,000-kw medium-wave transmitter operating on a frequency of 1,180 kc. Six rhombic antennas are used for short-wave coverage of Siberia, the Far East, China, and Central Asia. The medium-wave antenna consists of a 6-element array producing two beams directed towards China, Manchuria, Korea, Japan, and the Soviet Far East. This antenna permits a sky-wave radiated power in excess of 3,500 kw in certain directions and greatly reduces potential interference to other co-channel and adjacent-channel stations.

8. *Colombo, Ceylon.* This installation is primarily intended for coverage of India and Pakistan. The base consists of three 35-kw short-wave transmitters. Appropriate short-wave transmitting antennas are available for coverage of India and Pakistan and adjacent areas of Asia.

All of these eight relay bases described are under the control and operation of the U. S. Government. All supervisory and many of the operating functions are performed by American technicians.

9. *British Broadcasting Corporation (BBC) Relay.* In addition to these eight relay bases operated by the U. S. Information Agency, five 50-kw short-wave transmitters and appropriate high-gain curtain antennas beamed on Europe and the Near and Middle East, are leased by the U. S. Government from the BBC. These transmitting facilities are located at Woofferton, England, and are operated by British personnel on a contractual basis with the U. S. Information Agency.

The eight relay bases which have been described and the facilities leased from the BBC make up the present VOA system of overseas relay bases. Each base is so located as to take maximum advantage of favorable propagation conditions in receiving transmissions direct from the United States and simultaneously relaying them into selected target areas on either the short-, medium-, or long-wave broadcasting bands.

10. *The Courier.* The VOA also maintains a floating relay base on the U. S. Coast Guard *Courier*, which operates much like the fixed overseas relay bases. The vessel does not broadcast on the high seas but is intended to operate at fixed locations in harbors of friendly nations which have granted permission for such operations. The advantage of the *Courier* lies in its flexibility—as it can go into immediate operation as a fixed relay base as soon as it is anchored, eliminating the time lost due to the 12- to 18-month construction period usually required for building permanent relay bases.

The *Courier* is equipped with a 150-kw medium-wave

transmitter and two 35-kw short-wave transmitters. The vessel is equipped with a balloon-supported antenna that can be raised to optimum heights for medium-wave operation. There is also an emergency antenna on the ship for medium wave use when weather conditions do not permit use of the balloon antenna.

The installation aboard the *Courier* also includes diversity receiving equipment to receive programs for relay, a studio for local-program origination or for playing tape or disk recordings, a 5-kw transmitter used for radio Teletype communications, and three 500-kw synchronized diesel-driven generators to provide the power supply for the ship's broadcasting facilities. The *Courier* is presently in operation at the Greek Island of Rhodes, beaming VOA programs to the Middle Eastern and Balkan countries.

The overseas relay base system of the VOA, consisting of at least 47 high-power transmitters, has made bypassing of the auroral zones possible and has reduced the distance factor from transmitter to target area to values that are optimum for the effective delivery of broadcasts on short, medium, or long wave, whichever is popular in the selected target areas.

FEEDER BASES

THE OVERSEAS RELAY BASES of the VOA have just been described. These relay bases are the link in the over-all system directed towards the selected target area. The link from the United States to the relay bases is referred to as the "feeder" link in the over-all system. It consists of 30 high-power short-wave transmitters located at seven bases in the United States. These high-power transmitters employ high-gain directive transmitting antennas for the dual purpose of feeding program transmissions from the studios of the VOA to the overseas relay bases for simultaneous relay into selected target areas and also as a supplemental means of direct target area coverage during periods of favorable propagation conditions. The following facilities are used for this purpose:

1. *Bound Brook, N. J.* Six 50-kw short-wave transmitters and 17 high-gain antennas beamed towards Europe, North Africa, and South America.

2. *Brentwood, N. Y.* Three 50-kw short-wave transmitters and 19 high-gain antennas beamed towards Europe and South America.

3. *Schenectady, N. Y.* Three short-wave transmitters ranging in power from 25 to 100 kw and eight high-gain antennas beamed towards Europe and South America.

4. *Wayne, N. J.* Two 50-kw short-wave transmitters and four high-gain antennas beamed on Europe.

5. *Bethany, Ohio.* Six short-wave transmitters capable of operation at powers between 50 and 200 kw and 31 high-gain antennas beamed on Europe, Africa, and South America.

6. *Delano, Calif.* Five short-wave transmitters ranging in power from 50 to 200 kw and 17 high-gain antennas beamed towards Southeast Asia, the Far East, Siberia, and South America.

7. *Dixon, Calif.* Five short-wave transmitters ranging in power from 50 to 200 kw and 17 high-gain antennas beamed towards Hawaii, Australia, Southeast Asia, the Far East, and South America.

For the most part, programs of the VOA originate from a new studio installation in Washington, D. C. These new facilities consist of 16 studios, 10 recording rooms with equipment to make 40 disk or tape recordings simultaneously, 10 tape-editing booths, a recording control center, and the master control room. The remainder of the nearly 100,000 square feet in the Health, Education, and Welfare Building is devoted to editorial offices, music and transcription libraries, and other offices required to keep the VOA in operation 24 hours a day.

This rounds out the systems concept of the VOA world-wide international broadcasting network. VOA broadcasts originating in studios located in Washington, D. C., are fed through appropriate control equipment and landline circuits to any 1 of 30 feeder transmitters located at 7 plants in the United States. These programs are then broadcast over the high-power short-wave feeder transmitters, employing high-gain directional-antenna systems, to any 1 of 47 high-power transmitters located at 10 overseas relay bases throughout the world. These circuits to the relay bases by-pass the auroral zone of exceptionally heavy r-f absorption. The relay bases, located at optimum distances from the selected target areas, boost the level of the signal received from the feeder transmitters and simultaneously relay the broadcast directly into the target area on either the short-, medium-, or long-wave broadcasting band, whichever is popular for broadcasting in the target area itself. Often secondary target-area coverage is also obtained direct from the U. S. feeder transmitters during periods of favorable propagation conditions.

JAMMING

COMMUNIST JAMMING of VOA transmissions was first observed in February 1948. Since that time, jamming has continued and it is believed that the Communists are employing hundreds of radio transmitters to jam Soviet and European-satellite language transmissions of the VOA and other free world broadcasters. The jamming consists mainly of irritating sounds and noises on the same fre-

▶**Fig. 2 (top, opposite page). An arctic projection indicating the approximate location of the northern auroral zone. Cross-hatched area shows parts of the world that cannot be effectively reached from short-wave transmitters in the United States due to the shielding effect of the auroral zone. Note, however, that circuits from New York to Tangier and from San Francisco to Manila are not shielded by this zone. Fig. 3 (bottom, opposite page). The same map projection as Fig. 2 with the cross-hatched area indicating the auroral zone shielding effect upon short-wave transmissions from Tangier. Note that Asiatic and European areas shielded from direct coverage from the United States (see Fig. 2) can be covered from Tangier. For example, while the direct circuit from New York to Moscow is shielded by the auroral zone, the indirect circuit from New York through Tangier to Moscow clears the auroral zone**

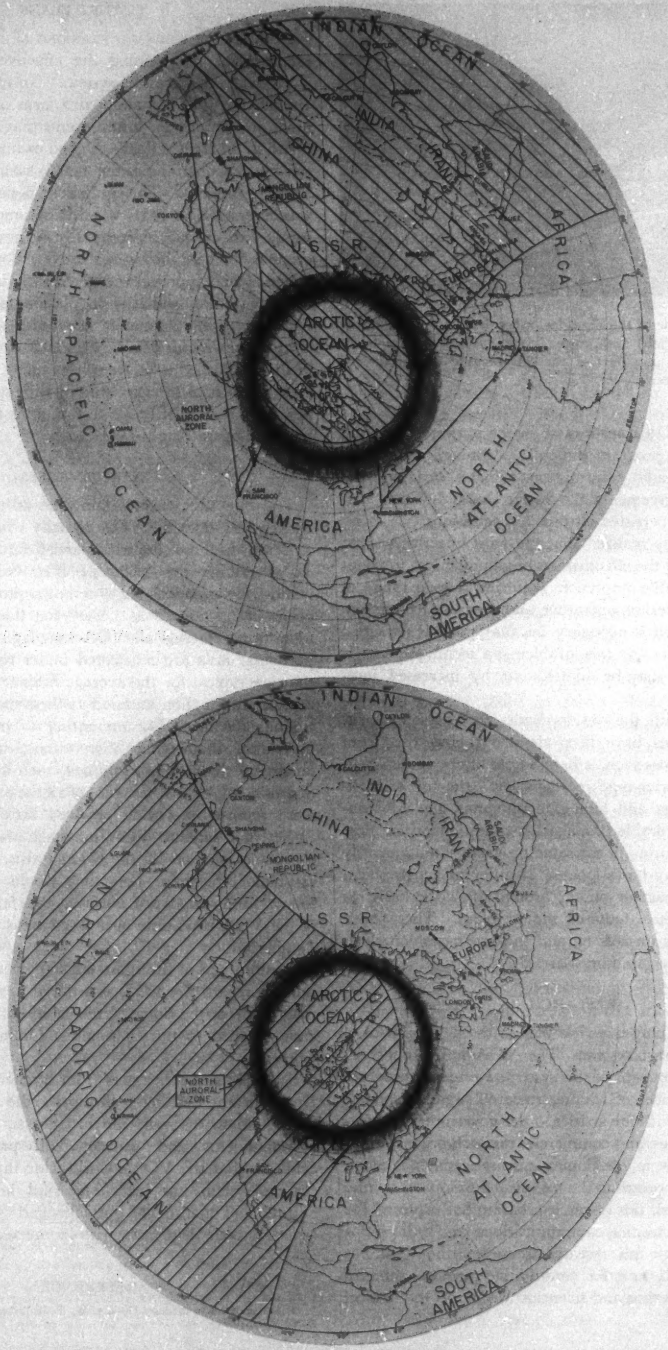
INDIAN OCEAN
INDIA
CHINA
IRAN
AFRICA
U.S.S.R.
MOSCOW
EUROPE
ARCTIC OCEAN
NORTH AURORAL ZONE
NORTH PACIFIC OCEAN
AMERICA
NORTH ATLANTIC OCEAN
SOUTH AMERICA

Fig. 4. Aerial view of the Tangier relay base showing transmitter buildings (left) and power plant and oil storage facilities (right) as well as a part of the 24 rhombic short-wave antennas in their system

quency as the VOA transmission for the purpose of making reception of the program difficult. Although intentional interference to radio transmissions violates certain international radio agreements, the Soviet Union and the satellite nations have persisted in these transgressions.

The VOA early realized that the most effective way to combat or nullify the effectiveness of jamming was to adopt a dynamic versatile approach requiring a wide range of latitude in engineering, operating, and program techniques. Such an approach is necessary because there is no single "magical" solution to this problem—a technique that is successful today may be blotted out by increased jamming tomorrow.

Concurrent with the development of the system itself, certain techniques have been devised taking the form of electronic devices such as heterodyne filters, speech clippers, exalted carrier-type receivers, etc., the use of high-power transmitters and high-gain antennas, the advantageous use of favorable propagation conditions when these exist, the transmitting of the same program simultaneously from various relay bases located at different geographical locations, broadcasting on an around-the-clock basis, as well as continuous study of the problem. These have permitted various degrees of, and in some cases complete, penetration of the jamming barrage.

RESEARCH

Research has played a vital part in the development of the VOA broadcast system. The VOA has established, during the development of this system, a research program utilizing the services of leading research organizations at various colleges and universities, other government departments and agencies, and commercial research organizations having experience in developing research activities along the lines most important to the technical development of the VOA. In general, this research program has explored the broad field of electronics, communications, and radio propagation. Through this research program, the VOA has also had available to it for consultative purposes some of America's engineering and scientific leaders in the field of communication.

FUTURE PLANS

Long-range forward planning of a dynamic nature is essential for maintaining the effectiveness of the VOA world-wide broadcasting system. To insure this the VOA engineering staff has adopted a form of "stockpile" planning, or planning for future events that may require or demand immediate action. A good example of the results of this type of planning is the new Washington studios of the Voice of America. The equipment design for these studios was completed in 1951, when it became obvious that new studio facilities would eventually be needed to replace the original VOA studios in use in New York City since 1942. When official approval was given early in 1954 to construct the new studio installation in Washington, D. C., these designs were available making it possible to begin equipment fabrication without delay. Similarly studio design requirements established a few years ago made it possible to complete the first of the new studios with speed and effectiveness, in a matter of less than 6 months time from drawing board to operational use.

EFFECTIVENESS

The question may certainly be asked whether all this is effective; does the VOA actually reach its target areas, especially in those countries under Communist domination? To determine the technical effectiveness of the VOA world-wide broadcasting system, monitoring stations have been set up to act as "ears" for the VOA. At these monitoring stations all VOA language broadcasts to the particular area are monitored under reception conditions that are typical for the average listener in the area. Reception information amassed at these technical monitoring stations during 1954, amounting to over a 1/4-million individual monitoring observations, indicated that on languages that are not jammed, such as French, English, Spanish, etc., over 90 per cent of all the programs monitored were reported as being received satisfactorily. On the Soviet and satellite VOA language transmissions, which are being jammed by the Communists, the percentage of satisfactory reception is, as one would expect, somewhat lower. Indications are, however, that fairly good reception of the VOA is possible over large areas under Communist domination.

Possibly one of the most tangible proofs that the Communists regard the VOA as a threat to their designs is the magnitude of the Soviet Union's effort to jam the broadcasts beamed to the Communist-dominated areas of the world.

Scientific surveys, letters from listeners, interviews with Iron Curtain defectors, efforts by the Communist press and radio to discredit the broadcasts, and reports from correspondents and travelers, all provide convincing evidence that the VOA's world-wide international broadcasting system has been successful in overcoming the natural and man-made obstacles and is getting through, to an appreciable degree, with its message from America.

REFERENCE

1. Punching Holes in the Iron Curtain, **W. T. Walker**. *Diesel Power*, New York, N. Y., March 1954.

Generator Eccentricity, Vibration, and Shaft Currents

L. T. ROSENBERG
MEMBER AIEE

ECCENTRICITY of the rotor causes pulsating unbalanced magnetic forces; induced currents in rotor winding, wedges, and surface; and circulating currents between stator circuits with consequent increased losses and temperatures. Inequality in the gap also affects the fringing fluxes at the core end region, and may result in high temperatures in clamping plates or retaining rings.

Concentricity should be established by careful measurement in at least four positions at each end of the generator. The procedure and tolerances recommended by the manufacturer should be followed initially as well as in subsequent reassemblies. Checking the gap at regular inspection periods is advisable because changes may occur because of settling or growth of the foundation, abnormal wear, or sudden shock.

The rotor should be well centered axially under all conditions to avoid end thrust, unbalanced end fringing flux, and abnormal local heating of the fingerplates and retaining rings. Adequate provision should be made for thermal changes in the turbine, and additional expansion of rotor when unit is loaded. Once stator location has been established, subsequent checking is seldom necessary except for adjustment of fan shrouds, baffles, etc., whenever they are disturbed.

The most common source of rotor vibration arises from dissymmetries that result in nonuniform weight distribution. Other causes have been traced to thermal or magnetic sources, to inequality in stiffness in the two axes, to improper adjustment of bearing clearances, and oil whip. Stator vibration in 2-pole generators sometimes results from the magnetic pull between rotor and stator in the air gap. In most large 2-pole machines, core vibration is isolated by means of a flexible support. Occasionally, parts of the wrapper plate or lagging may resonate at, or near, 120 cycles. The acceptable amplitude of these parts will depend upon their manner of support or the seriousness of the unpleasant noise.

Suddenly appearing or increasing vibration may be of greater significance than the steady continuous type. A history of vibration amplitudes is believed desirable for all machines. The first sign of short-circuited rotor turns may be increased rotor vibration. If the rotor has a temperature recorder, it may show a sudden drop in resistance. Rotor impedance at 110 volts and 60 cycles is sometimes useful for detecting rotor-turn short circuits by comparison with an initial reading. If short-circuited turns cause thermal unbalance, weight adjustments can sometimes be made to keep the amplitude within a satisfactory range for all temperatures. Increased rotor vibration could also indicate displacement of rotor coil blocking or physical damage to the shaft or fans. Such cases are unaffected by removal of excitation and often continue during retardation.

Sudden stator vibration might indicate unbalanced load or loosening of the core or other parts that have become resonant or are being rattled about by the ventilating gas. In double-winding machines, a characteristic noise can be heard when load is removed from one winding.

The most common cause of shaft voltages is inequality in reluctance of the parallel flux paths linking the rotor. If both bearings are grounded, substantial currents may flow through bearing oil films and damage the shaft journals and babbitt surface as well as other parts. Consequently, the outboard end of the rotor is usually insulated from ground.

Shaft currents can also result from a magnetized shaft, bearing pedestal, or end cover. Cases of magnetized shafts, bearings, and end covers have resulted from the dryout of stator windings using direct current, or from double ground faults in rotors. Bearing currents have been found to originate from electrostatic charges generated within the steam turbine. Abnormal wear of worm gears as well as objectionable radio and television interference have been traced to this source. The remedy is a grounding brush somewhere on the shaft or spindle.

There are various means to check the insulation of the outboard bearing while the unit is running. One consists of two successive measurements of voltage, the first from a sliding contact on the shaft to ground at the outboard end of the rotor, and the second from the pedestal to ground with a dead short circuit from sliding contact on the shaft to the pedestal. Bearing insulation is satisfactory if readings are alike and short-circuited if the second is lower than the first. The insulation can sometimes be checked while machine is running by touching a grounded wire to the shaft to see whether a spark occurs. The absence of sparking may be an indication of faulty insulation.

Insulation of pipe joints may be checked with a couple of dry cells connected from pedestal or end cover to a point on the pipe, and a d-c millivoltmeter connected across a length of pipe between flange and one battery connection. If the flange insulation is defective, the battery will force current along the pipe to the insulated pedestal or end cover, and the meter gives the voltage drop.

Common causes of faulty bearing or seal insulation are metallic slivers, embedded thermocouples, graphite or paint on insulating material or pipe flanges, as well as dirt, moisture, or foreign matter.

Digest of paper 55-121, "Eccentricity, Vibration, and Shaft Currents in Turbine Generators," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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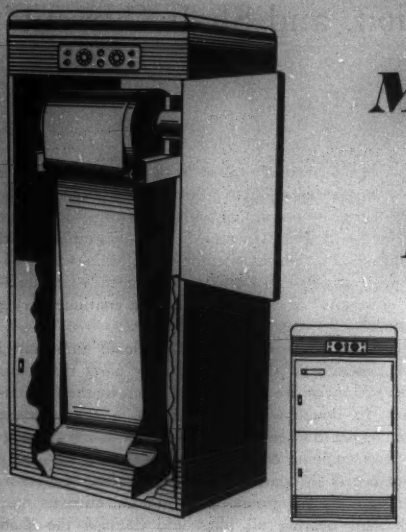
During the preparation of the AIEE Guide for Operation and Maintenance of Turbine Generators by the Synchronous Machine Subcommittee of the Rotating Machinery Committee, the committee decided to submit a paper to the members for the purpose of bringing forth discussion that could be incorporated in the Guide.



Magnetic Memory Device for Business Machines

by S. J. BEGUN

This magnetic storage device combines the access-time advantages of a magnetic drum and the storage-capacity advantages of a tape recorder. All information is recorded on an endless magnetic tape which is divided into a series of pages. A desired page is wrapped around half of a rotating drum to be inspected by heads mounted on the drum.

AS PEOPLE IN INDUSTRY AND LABORATORIES have become more familiar with memory systems, the demand for storage devices of considerable capacity with a relatively fast random access time to the recorded information increases from day to day. Magnetic drums have been built with a diameter and length of a few feet capable of memorizing 2 to 3 million binary digits; but if the diameter of the drum needs to be more than a few inches, the device becomes expensive to manufacture. Out-of-round tolerances must be kept to 0.001 inch. This requirement for high accuracy is necessitated to keep the distance of 0.001 to 0.002 inch of the magnetic heads from the periphery of the drum reasonably constant while it rotates under the stationary heads.

Since the total storage capacity of a drum is limited to what can be accommodated on its periphery, it has been suggested that drums be made long and their radius small to reduce space requirements to a minimum. However, such a construction has serious disadvantages since it requires additional recording and playback heads and more electronic switching equipment.

About 100 magnetic pulses per lineal inch and ten parallel channels per inch width can be accommodated. This means that 1,000 binary digits can be stored per square inch of magnetic recording surface. Even if the pulse density should be substantially increased in the future as better techniques are developed, it is still difficult to see how a system of conventional magnetic drums can be made economical if 10^8 to 10^{11} digits have to be memorized as is required in many inventory and business applications.

THE ENDLESS-TAPE MEMORY UNIT

AS AN ANSWER to some of the problems posed by the conventional magnetic-drum design, a new type of magnetic-storage device has been built which combines the advantages of a magnetic drum in terms of access time with the advantages of a tape recorder in terms of storage capacity. In this device, called the TapeDRUM*, all information is recorded on an endless magnetic tape from 10 to 12 inches wide and from 8 to 450 feet long. The tape is stationary and wrapped around half a rotating drum as shown in title picture. The drum has a 12-inch diameter and rotates at a speed of 1,200 rpm. The portion of the tape in contact with the drum is scanned by a series of magnetic heads with all their gaps aligned and with their pole pieces extending only slightly above the drum surface. Fig. 1 shows the heads mounted on the drum. The magnetic layer of the tape is turned away from the drum. During operation, the tape is lifted slightly from the drum surface by a thin air cushion caused by a boundary layer. This assures long life of the recording medium since not even the base material experiences much wear.

Du Pont Mylar polyester film with its great physical strength and with its high resistance to temperature and humidity changes is well suited in this application as a base material for the magnetic tape. With a film thickness of about 0.001 inch and an air cushion of about half this dimension, the spacing between magnetic heads and magnetic layer is approximately the same as the spacing between

Essentially full text of conference paper CP55-243, "A New Magnetic Memory Device for Business Machines," presented at a session of the AIEE Committee on Computing Devices, AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1955.

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*Trade-mark of Clevite-Brush Development Company.

heads and magnetizable material in a conventional magnetic drum. Accordingly, the same number of pulses per square inch can be handled by both types of memory systems. Fortunately, considerably larger out-of-round tolerances are permissible in the TapeDRUM proposed here. The inertia of the tape resting on the drum is low enough to make the recording medium follow those motions of the drum which might be caused by a slight eccentricity.

Each head rotating at 1,200 rpm and mounted on a 12-inch-diameter drum scans 1 lineal inch of tape in 1.33 milliseconds. Therefore, when 100 digits are recorded per inch, the time required to cover the center-to-center distance between two adjacent pulses is close to 13 microseconds. The magnetic head must be capable of working in the megacycle range and, thus, must have low losses at high frequencies. Heads with ferrite pole pieces give adequate service. Those used in the TapeDRUM have a pole-piece width of 5×10^{-3} inch and carry 200 turns. Their playback peak-to-peak level reaches 20 to 40 millivolts. A recording current from 50 to 100 milliamperes is sufficient to impress a saturating signal on the tape.

When square waves of 1-microsecond duration are recorded, the reproduced signal is a positive pulse followed by a negative one as shown in Fig. 2. The playback pulse duration is approximately 10 microseconds. Before the storage capacity in the direction of tape motion can be much increased, the reproduced signal must be substantially shortened.

To compensate for the eccentric mechanical load due to the head assembly, the drum is dynamically balanced. Each head is firmly secured to the rotating structure and so designed that it can withstand centrifugal forces of approximately 250 G's. Reliably operating slip rings are provided to connect the head windings with the associated electronic equipment.

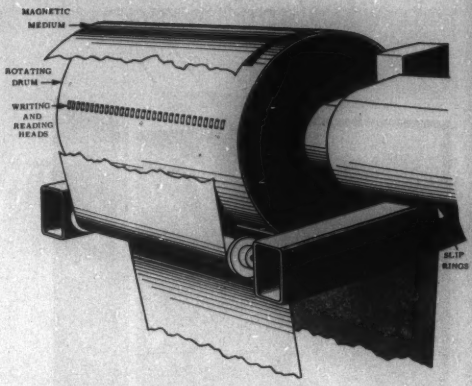

Fig. 1. Rotating drum with magnetic heads

THE PAGE INDEX SYSTEM

THE TAPE PORTION resting on top of the drum might well be thought of as a page. The total length of the endless tape is thus subdivided into many pages. This is schematically shown in Fig. 3. Though half of the surface of the cylinder is covered by the recording medium, not all of the corresponding tape area constitutes a page. To allow for variation in lengthwise positioning of each page, an unrecorded section approximately 1 inch wide and extending over the complete width of the tape is sandwiched between adjacent pages. With a drum having a 12-inch diameter, the surface area of one page is approximately 200 square inches and, thus, 200,000 individual magnetic pulses can be stored. An endless tape of 50-foot length will hold about 16 pages and, thus, will memorize 3 million binary digits of information. A page is inspected every 1/20 of a second by the swirling heads. The access time to information on each page is thus comparable to that of a conventional magnetic drum.

Provisions have to be made to select any one page by

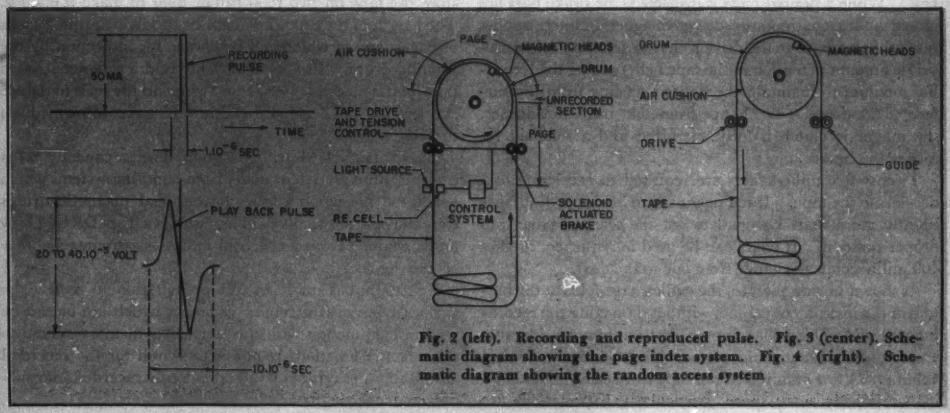

Fig. 2 (left). Recording and reproduced pulse. Fig. 3 (center). Schematic diagram showing the page index system. Fig. 4 (right). Schematic diagram showing the random access system

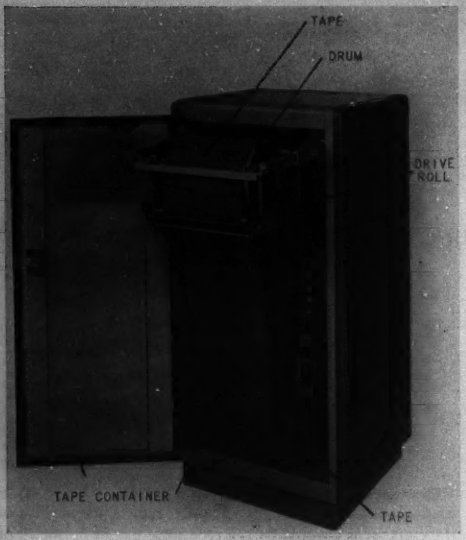

Fig. 5. TapeDRUM shown mounted in open cabinet

suitable coding methods and make it come to rest on top of the rotating drum. This is done, as indicated in Fig. 3, by a photoelectric control system though stationary magnetic heads might have been used instead to fulfill the same function. The photocell correlates transparent portions in the unused tape section between pages with the page location and makes the proper page come to rest over the drum so that the rotating heads can read or record the desired information.

For moving and stopping the tape, a system is employed which consists of two drive rollers on one side of the rotating drum and two brake bars on the other side of the drum. The rollers and bars extend over the full width of the tape belt. While a desired page is inspected, the brake bars are closed and a continuously driven magnetic clutch applies just enough torque to the drive rollers to generate the appropriate amount of tension in the tape belt, causing the recording medium to maintain the desired spacing from the surface of the drum. To change from one page to another, the magnetic clutch is fully energized and a solenoid removes the brake.

Twenty-five milliseconds are required to accelerate and decelerate the tape. If ten pages are to be skipped, it takes slightly more than 1 second to get the selected page into proper position. If pages can be used in sequence, it takes 400 milliseconds to change from one to the next.

As shown in title picture, the endless tape folds at the bottom of the instrument cabinet without damaging the recording material. This makes it possible to store a considerable amount of magnetizable surface area within a limited volume. A few hundred feet of tape can be accommodated in a relatively small space, particularly if provisions are made to maintain control over the folding process within the housing of the device.

THE TAPEDRUM AS RANDOM-ACCESS MEMORY

In a system in which pages are used, the data are preferably recorded in accordance with a predetermined order. In this way the information is accessible by the proper choice of three parameters, namely, the page, the column, and the angular position of the drum. It is, however, not always possible to have the information recorded in a specified manner. This is particularly so if the application requires a random search for recorded data. In this instance the tape moves continuously in a direction opposite to the rotation of the drum as schematically illustrated in Fig. 4. The speed of the endless recording medium is so chosen that every bit of information on the recording medium can be inspected at least twice by the heads while the tape advances over the scannable distance. This permits reading the information and subsequently making changes if they should be required. To accomplish this, the linear tape velocity must be a quarter of the peripheral drum speed or approximately 15 feet per second.

A recent study of some business requirements has shown that a maximum access time of 30 seconds and an average access time of 15 seconds is frequently tolerable. Thus, a tape length of approximately 450 feet can be used, accommodating 60 million binary digits on the basis of 1,000 pulses per square inch.

While the various illustrations show only one set of heads on the drum, it is entirely practical to have two rows of them displaced 180° from each other. One head of the first row reads the same column as a corresponding head of the second row. This makes it possible to inspect a page at twice the speed, namely, every 1/40 of a second. Since all heads of each row are aligned, stretching does not interfere with the reliable operation of the instrument.

The recording medium can also be wrapped around the drum for more than 180°. This increases the scannable area of each page but eliminates the use of more than one row of heads.

For certain applications it has been found practical to store the tape on two reels rather than to make it endless. The length of the tape can again be subdivided into a series of pages, any of which can be chosen for inspection by the rotating drum. In a device of this kind a servo-controlled tape loop is placed between the drum and the reels to reduce acceleration and deceleration times of the recording medium to a minimum.

The TapeDRUM with its great storage capacity is an extremely useful tool for many data-handling systems which would be uneconomical if conventional magnetic drums were the only alternative. Fig. 5 shows a TapeDRUM now under study. Experience so far indicates extreme reliability of the device.

No attempt is made in this presentation to review the various types of electronic equipment which are or can be used in conjunction with this particular memory system to perform the functions required to search for the recorded information, to reproduce the previously recorded information contents, and to write in new data.

Automatically Switched Capacitors on a Single Feeder

W. C. FOWLER
MEMBER AIEE

C. W. THOMAS

THE BENEFITS obtained by the use of capacitors on the electrical utility system are well established, as well as the experience that dictates that the capacitors should be disconnected from the circuits when they are not needed. This requirement for switching both on and off has resulted in applications that are determined by the selection of control means, and not always at the point of maximum effectiveness in the supply of reactive loads and voltage improvement.

A new device is available in which the speed of response in switching capacitors is decreased logarithmically as the signal strength approaches the contact setting of the control. The signal function of the new unit may be voltage, current, watts, or vars. Its time characteristic suggests the possibility of using several such units on the same circuit to obtain selective switching of capacitor banks that may be relatively near each other and closely located to the point where reactive supply is needed.

One distribution feeder in Bartlesville, Okla., was selected as a typical circuit for experimenting with the application of several such control units. This 4,160-volt feeder has induction regulators ahead of the first customer and a normal diversity in types of customers supplied.

Immediately after the regulator station, a bank of capacitors was installed and controlled by the measurement of reactive load. Three other banks of capacitors were connected at points farther along the circuit, each bank being controlled by a voltage-measuring control unit. Fig. 1 shows the installation of control unit and graphic thermal voltmeter at one station of this type. Records were also maintained as to watt and var loading and the times various controls switched their capacitor banks.

Numerous combinations were used at various times to determine the effects of different settings of the control units with similar experiments with respect to adjustments of line-drop compensation in the regulator.

Fig. 1. Voltage control and graphic voltmeter

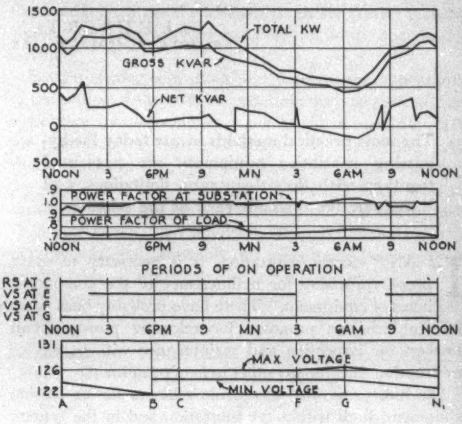

Fig. 2. Voltage chart showing operation and results

Feeder 2, Bartlesville, Okla., September 2–3, 1954. Settings: RS Station C, On—280 volts, Off—120 volts; VS Station E, On—124½ volts, Off—126 volts; VS Station F, On—124 volts, Off—125½ volts; VS Station G, On—124¾ volts, Off—126½ volts.

Results of greatest significance were noted when the regulator was operated with a relatively narrow bandwidth and no compensation, and with voltage controls of approximately the same bandwidth operating at their respective locations, as shown in Fig. 2. This combination resulted in the switched banks of capacitors providing steps in voltage control and allowing the regulator to operate as a vernier to bridge those steps. The effective bandwidth along all of the circuit between regulator and the last bank of capacitors was held to surprisingly close limits, and also with very high power factors observed at regulator and at the source of the circuit.

REFERENCES

1. Power System Voltage Control Without Feeder Voltage Regulators, **N. N. Smeloff.** AIEE *Transactions*, vol. 67, pt. II, 1948, pp. 1462–6.

2. An Evaluation of Power Factor Correction on a System Basis, **H. B. Tomlinson, R. O. Bigelow.** AIEE *Transactions*, vol. 73, pt. III, 1954 (January 1955 section), pp. 1676–83.

3. Application of Shunt Capacitors at Transmission and Distribution Stations, **F. M. Porter, C. P. Zimmerman.** AIEE *Transactions*, vol. 70, pt. I, 1951, pp. 112–20.

4. Thermal Meters Control Capacitor Switching, **J. H. Patton.** *Electrical World*, New York, N. Y., vol. 141, no. 10, March 8, 1954, pp. 103, 107.

5. Lincolntrol as Used for Capacitor Switching. *Bulletin 492*, Sangamo Electric Company, Springfield, Ill., 1954.

Digest of paper 55-91, "Automatically Switched Capacitors in Step on a Single Distribution Feeder," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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Methods of By-Passing Distribution Substation Equipment

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The most practical methods in use today for by-passing substation equipment are presented together with the advantages, limitations, and comparative costs for each of the schemes.

IN ANY electric substation, it is necessary to make proper provision for maintenance of the component items of equipment. There have probably been more different schemes proposed for releasing power circuit breakers for inspection and maintenance without service interruption than for any other item of equipment.

The most generally acceptable schemes for by-passing equipment, both within the substation and in the system, have the following advantages and limitations.

OUTDOOR CONVENTIONAL SUBSTATIONS

WHERE outdoor frame-mounted oil circuit breakers have been installed in conventional structures with open bus work on porcelain insulators, it has often been the practice to include auxiliary and transfer busses, disconnecting switches, by-pass switches, and duplication of equipment. In this type of construction such duplicate features can be included to permit removing a breaker from service for maintenance purposes, to permit service to be restored more quickly after failure of some component, and possibly for an added sense of security.

Substations of this type with 1-line diagrams similar to that shown by Fig. 1 are not uncommon. The operation of a substation of this type is somewhat complicated and confusing, especially under emergency conditions. With substations of this type, operators have been known to make errors resulting in loss of additional load and possibly some damage to equipment or injury to themselves. The substation may become so burdened with additional busses and disconnecting switches that it becomes difficult to operate with safety, and the duplication of facilities with complicated interconnections may actually result in a decrease of service continuity instead of an increase.

With the increased reliability of electric equipment, there is a trend toward simplification of the 1-line diagram of conventional substations with a bare minimum of duplication of equipment in the substation.

Instead of providing by-pass or duplication of facilities within the substation, it is becoming increasingly popular to perform such by-pass facilities in the form of cutover switches out on the feeder circuits. These cutover switches permit tying together feeders from the same substation. A more preferable arrangement is to be able to tie together feeders fed by different substations. This latter arrangement not only allows load to be served during periods of normal breaker maintenance, but also for such purposes as transformer maintenance, bus maintenance, addition of feeders, or even to pick up load quickly after failure of some item of substation equipment.

Overhead feeder circuits often overlap slightly or come within short distances of each other, and very little, if any, additional line construction is necessary to make such cutover facilities possible. As a matter of fact, these cutover facilities are generally built into distribution feeder systems anyway for use during line outages. The actual switching may be done by pole-mounted porcelain cutouts with solid blades, hook-operated disconnecting switches, or group-operated horn gap switches.

OUTDOOR FACTORY-ASSEMBLED SUBSTATIONS

WITH the outdoor substations using metal-clad switchgear, it is also desirable to be able to remove breakers from service for maintenance without interruption of service; however, the following conditions are different as compared to the outdoor conventional substations with oil breakers:

1. Metal-clad switchgear normally uses air circuit breakers which require less frequent inspection and maintenance than oil circuit breakers.

2. Metal-clad switchgear breakers are easily removable. In many cases a spare removable breaker element is used to replace a breaker. The breaker taken out of service may then be inspected on the site or taken to a remote maintenance shop. In this case, it is necessary to carry the load by some means only for the few minutes required to interchange breaker elements, while it may require several hours to do maintenance on a frame-mounted oil breaker in a conventional substation. Occasionally, it may be satisfactory to de-energize the feeder for the few minutes required to remove a breaker and replace it with a spare element. For example, this would be true for feeders supplying 208Y/120-volt secondary network transformers since the load would continue to be supplied by other sources feeding the network. In other cases, a spare breaker

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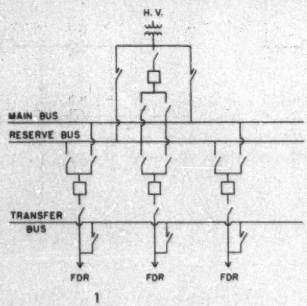
element may not be available and it may be required to carry the load by some other means for the length of time required to perform the breaker maintenance.

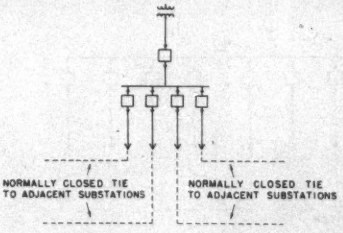
3. In metal-clad switchgear, every provision is made to keep the main bus as reliable as possible. It is insulated and metal enclosed to protect against access by foreign objects, moisture, dust, and rodents. The bolted joints do not require periodic checks for tightness. Tap-off connections to breakers are kept as short as possible. For these reasons, there is little cause to require de-energization of this main bus with the possible exception of adding feeders.

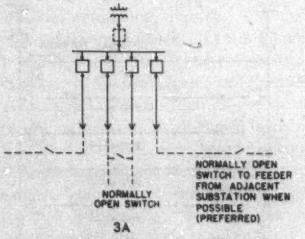
4. Gang-operated disconnecting or by-pass switches in metal-clad switchgear are undesirable for the following reasons: (a) blades of the switches cannot be insulated as are all other parts of the energized circuit and thus the switch becomes the weakest link in the switchgear assembly so that instead of providing increased service reliability, the addition of such devices may result in decreased reliability; (b) incorrect operation of such a device with little or no interrupting capacity is much more serious inside a metal enclosure than when mounted on an open switching structure; (c) connection of such a device directly to the main bus is to be avoided since it increases the exposure and reduces the integrity of the bus; (d) switching should preferably be done by full-capacity breakers, in keeping with the increased safety and reliability associated with metal-clad switchgear; and (e) cost of including such switches in the standardized metal enclosures is usually greater than including the same switching functions out on the open feeder circuits.

5. To reduce congestion and improve the appearance of the station, a majority of feeder circuits leave metal-clad switchgear by underground cable and then up a riser pole for connection to overhead open-line construction. Although faults in such riser cables may be uncommon, they are time consuming to repair. Breaker by-pass facilities included inside the metal-clad switchgear do not by-pass these riser cables. With cutover facilities out on the feeder circuits, a faulted riser cable can easily be disconnected and service restored while cable repair is being made.

For these reasons, it is the general practice to provide







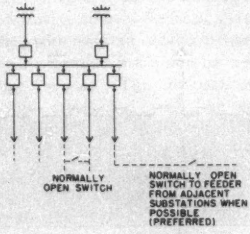


Fig. 1. Typical conventional substation. Fig. 2. Primary network substation. Fig. 3. (A) radial substation. (B) single-circuit integral-unit substation, with breaker by-pass switch. Fig. 4. Spot network substation

duplication of service of by-pass facilities remote from unit substations with metal-clad switchgear. However, for some applications, the breaker by-pass facilities must be provided inside the substation. An example would be a substation which feeds circuits which are completely underground.

For certain types of substations, by-pass facilities are automatically included for feeder breakers because of the inherent substation characteristics.

STANDARD TYPES OF SUBSTATIONS AND SWITCHGEAR

THE different standard types of the unit substations and metal-clad switchgear are shown in 1-line diagram form by Figs. 2 through 12. Each of these will be reviewed to see how feeder breaker by-pass facilities can be provided.

Primary Network Substation (*Fig. 2*). Most feeders from this type of substation are also fed at the remote end by other substations. This means that the feeder breakers can be tripped and removed for maintenance without any special provision being made since the feeder will continue to be fed from the other end. The system provides by-pass facilities for feeder breakers, and allows any substation transformer or bus to be taken out of service also without interruption to any portion of the load. No special by-pass or cutover facilities are required either at the individual substations or out on the feeders. This represents the ideal condition as far as by-pass facilities are concerned, both for feeder breakers and also for other equipment.

Radial Substation (*Fig. 3*), *Spot Network Substation* (*Fig. 4*), *and Low-Voltage Selective Substation* (*Fig. 5*). These three substations are grouped together because conditions for by-passing feeder breakers are identical. With the single-bus substations shown, feeder breaker by-pass is usually provided remote from the substations out on the system. This is indicated by the normally open switches on the 1-line diagrams.

The feeder cutover facilities provide a means for by-passing both feeder breakers and riser cables. It is preferred that the cutover switches tie together feeders from different substations (or opposite bus sections on low-voltage selective substations), since this also provides a means for

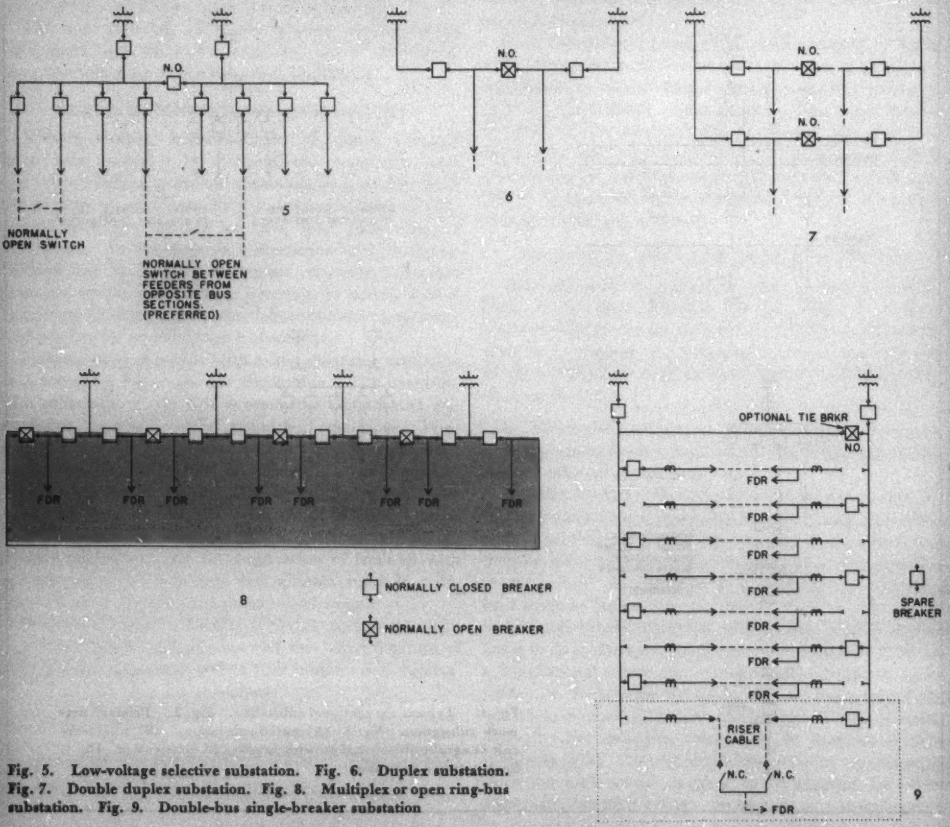


Fig. 5. Low-voltage selective substation. Fig. 6. Duplex substation. Fig. 7. Double duplex substation. Fig. 8. Multiplex or open ring-bus substation. Fig. 9. Double-bus single-breaker substation

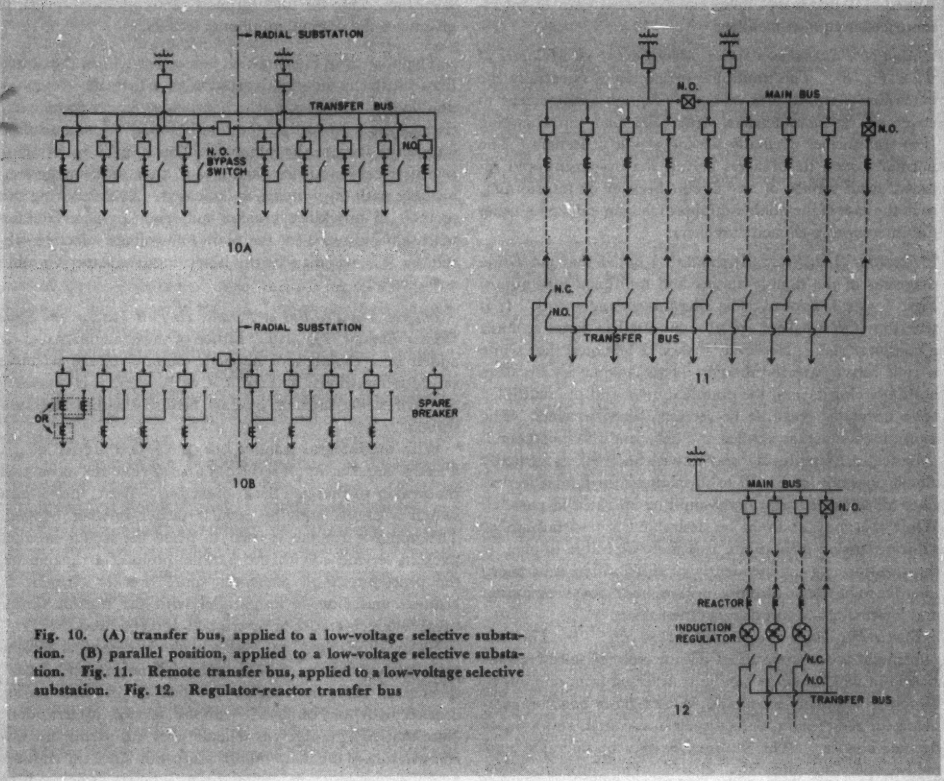


Fig. 10. (A) transfer bus, applied to a low-voltage selective substation. (B) parallel position, applied to a low-voltage selective substation. Fig. 11. Remote transfer bus, applied to a low-voltage selective substation. Fig. 12. Regulator-reactor transfer bus

picking up load in case of trouble at either substation or bus section.

If remote feeder cutover facilities are not used, there are three alternates remaining, namely: (1) use a portable mobile unit substation to pick up feeders one at a time; (2) add a transfer bus or parallel by-pass positions and spare breaker element, as discussed later; or (3) choose a different type of substation or system such as shown by Figs. 2, 6, 7, 8, 11, or 12, as individually discussed later.

For the double-transformer spot network and low-selective-voltage substations, the transformers and secondary breakers can be taken out of service by transferring all load to the second transformer. No transformer secondary breaker is shown for the radial substation, but if it is included it can be de-energized by connecting all feeders to remote substations by remote cutover facilities or by using a mobile substation to by-pass both the radial substation transformer and secondary main breaker.

A modification of the radial-type substation is the single-circuit integral-unit substation. It is a self-contained substation which can be installed or removed as a single unit. With its single radial feeder, its widest application is in light-load-density areas where 1,000 to 5,000 kva is to be served. If there are no feeders from other substations near enough to provide cutover facilities, the standard unit may be furnished with a circuit breaker by-pass switch (Fig. 3*A*) which permits breaker inspection or maintenance without interrupting service. The by-pass switch should be mechanically interlocked with the circuit breaker to prevent operation of the switch while the breaker is open. During the time when the by-pass switch is closed, feeder faults must be cleared by some protective device on the primary side of the substation.

Duplex Substation—Two Feeders (*Fig. 6*), *Double-Duplex Substation—Four Feeders* (*Fig. 7*). These two substations have internal provision for by-passing any circuit breaker, transformer, or auxiliary equipment for maintenance. The tie breakers are normally open. If it is desired to remove a feeder breaker for maintenance, a tie breaker can be closed under manual control and the feeder breaker tripped and removed. Note that this operation is completed by using full-interrupting-capacity breakers instead of limited-interrupting-capacity switches. Any false operation will result only in unnecessary dropping of load but with better safety to operators and equipment. Since the by-passing is done inside the substation, the riser cables are not in-

cluded. If necessary, these can be taken care of by remote feeder cutover facilities.

Multiplex Substation—Six or More Feeders in Multiples of Two (Fig. 8). The multiplex substation is essentially the extension of the duplex or double-duplex arrangement to cover six or more feeders, with each load tap changing (ltc) transformer normally serving a pair of feeders. The normally open tie breakers permit the by-passing and removal from service of any circuit breaker or transformer, as in the case of the double-duplex arrangement, again using full-interrupting-capacity breakers.

Ring-Bus Substations. It should be noted that the 1-line diagrams of the double-duplex and multiplex substations, Figs. 7 and 8, appear to be ring-bus arrangements. It is true that the breakers are all connected in series to form a complete ring. However, it should be noted that while a ring bus is usually thought of as having all breakers normally closed, both the double duplex and the multiplex have normally open tie or sectionalizing breakers. The multiplex is sometimes called an "open ring-bus substation."

Basically, a ring-bus substation with all breakers normally closed does not lend itself to supplying distribution feeders since all source transformers would be operated in parallel. While this may at times be desirable for transmission or subtransmission substations, it is more desirable to operate the transformers independently at distribution substations in order to have two or more levels of bus voltage regulation and lower short-circuit duty on the feeders.

Double-Bus Single-Breaker Substation (Fig. 9). This arrangement is an extension of the low-voltage selective substation in which feeders can be transferred from one bus to the other. This is accomplished by having two compartments for each feeder, one on each bus section, and a single breaker element. The tie breaker may be operated normally open or normally closed. The procedure for transferring a feeder to the opposite bus is to place the spare breaker element in position and close it in parallel with the regular feeder breaker, thus allowing the regular breaker to be tripped and removed from the cubicle without interrupting service. If it is desired to de-energize one bus for addition of new feeders, etc., the breaker element which is not in use is then used to transfer the next feeder, and so on, until all feeders are connected to one bus. To de-energize a transformer, the tie breaker would be closed and the transformer breaker opened. Therefore, it is possible to by-pass any of the equipment within the substation using only full-interrupting-capacity breakers and without de-energizing any feeder. By including a complete set of relays for each breaker compartment it is also possible to permit complete testing of feeder breaker trip circuits and associated relays.

If service requirements should change in the future, the double-bus single-breaker substation can be modified to give either of the following arrangements:

1. Double-bus double-breaker scheme can be obtained by adding breaker elements to all compartments, and operating them normally closed.

2. Standard low-voltage selective arrangement can be obtained by adding breaker elements to all compartments and eliminating the underground cable interconnection, to give twice the original number of feeders.

The portion of Fig. 9 which is enclosed within the dotted lines illustrates another variation of either the single- or double-breaker scheme which provides for by-passing the riser cables. Instead of the underground interconnections within the station, the interconnection is made by bringing two riser cables out for each feeder, then making the connections with the switches as indicated. By comparing this method of providing breaker and riser by-pass facilities with that indicated for the plain low-voltage selective substation, it is evident that the latter does the same job more economically.

Integral Transfer Bus or Parallel By-Pass Position and Spare Breaker Element (Fig. 10). Either of these methods can be added to a radial, spot network, or low-voltage selective substation as shown by Figs. 3, 4, or 5, where it is necessary to have feeder-breaker by-pass facilities within the substation.

With the integral transfer bus, the procedure for taking a feeder breaker out of service is first to close the associated tie breaker to energize the transfer bus. Next, the by-pass switch is closed and the regular feeder breaker tripped. The opposite routine is used to place the feeder breaker back in service. With the parallel-position arrangement, the procedure is to place the spare breaker element in position and close it in parallel with the regular feeder breaker which can then be tripped and removed.

It should be noted that both schemes as described accomplish exactly the same result; namely, picking up a feeder through a separate breaker so that the normal feeder breaker can be removed without service interruption. Note that the transfer bus scheme does not permit the de-energization of the main bus for inspection since the transfer bus must be energized from the main bus. The transfer bus also has the disadvantage of requiring a more involved operating sequence and with the penalty that when returning the normal feeder breaker to service, if the by-pass switch should be opened while the normal breaker is open, a failure and damage to equipment will probably result. A mechanical interlock should be provided to help prevent operation of the switch unless the feeder breaker is closed, but this cannot be a positive interlock as a feeder fault may trip the breaker while the switch is being operated. As pointed out previously, the group-operated disconnecting switches are not in keeping with the safety and reliability associated with metal-clad switchgear and should be avoided if possible.

The transfer bus arrangement permits complete testing of the feeder-breaker trip circuits and the associated relays. For the parallel-position scheme this testing can be done if duplicate current transformers and relays are furnished for every breaker position (two sets of current transformers and relays per feeder).

As shown in Fig. 13, the installed cost for the parallel-position scheme is about equal to the transfer bus scheme, and therefore should be used since it has operating advantages. The parallel-position scheme does take more space and larger foundation because of the extra compart-

ments; however, this is offset by the lower equipment cost and operating advantages.

The transfer bus scheme is sometimes considered without the bus tie breaker shown between the main and transfer bus. In this case, the procedure would be to close two by-pass switches and trip the feeder breaker to be maintained. This means that two feeders are tied together through the transfer bus and fed through one feeder breaker the same as if cutover facilities were used external to the substation out on the feeders. It should be noted that this usage of the transfer bus does not give the same operation as the parallel position, because two feeders are tied together and fed through one breaker, resulting in greater loss of load in case of a persistent fault. Also, there is an operating disadvantage and danger in the use of the two by-pass switches.

The parallel-position scheme therefore has the advantage of safety, reliability, operating convenience, and sometimes cost; and where by-pass facilities are required within the substation, it is preferable to the transfer bus in metal-clad switchgear. Neither arrangement makes any provision for riser cable repair.

There is one further possible advantage in the parallel-position arrangement. In the future, if remote feeder ties should become practical, the extra metal-clad positions can be very economically converted into additional complete feeder positions by removing the feeder-side bus work, adding current transformers, cable termination, relays, and breaker elements.

Remote Transfer Bus (*Fig. 11*). The remote transfer bus arrangement is effectively the same as the transfer bus of Fig. 9, except that the transfer bus is located in a separate metal-clad housing remote from that of the main bus. The operation of the two arrangements is the same; however, the remote transfer bus provides the added isolation between the busses. The remote bus scheme is more expensive than either the integral transfer bus or parallel-position arrangement.

Regulator Reactor-Transfer Bus (*Fig. 12*). If both individual feeder voltage regulation and feeder breaker by-pass facilities are required within the substation, the regulator reactor-transfer bus can be added to any of the radial, spot network, or low-voltage selective type of substations.

With this arrangement, there are two parallel line-ups of equipment, the normal transformer and metal-clad switchgear with underground cable connection from each feeder breaker to the transfer bus line-up with transfer switches and 3-phase induction voltage regulators. Each regular normally has all three phases geared together and operated from a single-phase control. However, if required, three separate controls can be furnished to give individual phase voltage regulation on each feeder. Reactors can be included if required to help protect the regulators from greater than 25 times full-load current. Riser cables then connect from the transfer bus line-up to the overhead feeder circuits.

Referring to Fig. 12, normal operation would be with the upper transfer switches closed and the lower switches open. The bus tie breaker shown at the right of the diagram would be open and the transfer bus de-energized. Each feeder would be fed through its feeder breaker and regulator. The procedure for removing one feeder breaker and regulator from service is as follows: (1) set regulator on neutral position; (2) close tie breaker to energize transfer bus; (3) close lower switch to connect feeder to transfer bus; (4) open upper switch to shunt load through tie breaker and transfer bus; and (5) trip feeder breaker to de-energize regulators.

The same steps in reverse order would be taken to place the feeder regulator and breaker back in service. If voltage regulation is required during the time that feeders are connected to the transfer bus, a regulator can be installed in series with the tie breaker; however, this is not shown on Fig. 12.

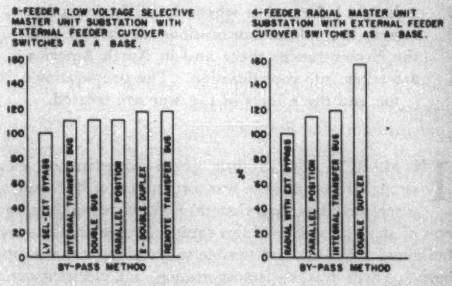


Fig. 13. Comparative costs of various methods for by-passing feeder breakers. *A—8-feeder low-voltage selective master unit substation with external feeder cutover switches as a base. B—4-feeder radial master unit substation with external feeder cutover switches as a base*

This arrangement has its place where individual feeder voltage regulation is required and in such case it also makes provision for by-passing both the feeder regulators and feeder breakers. Is not generally an economical scheme to use for providing only feeder breaker by-pass within the substation.

COST OF VARIOUS BY-PASS FACILITIES

THE GRAPH in Fig. 13*A* gives an approximate comparison of the costs of the various methods of obtaining breaker by-pass facilities within and external to the substation. To provide a base for comparison, an outdoor low-voltage selective substation was selected, having two ltc transformers each rated 7,500/9,375 kva, 34.4/4.16 kv, and eight feeders. These cost figures include only the transformers and the 4.16-kv switchgear and by-pass facilities, which consist of four pole-top switches remote from or adjacent to the substation, and disconnect switches at the end of each riser. Because of the wide selection of available primary protection, the high side equipment was not included in the cost.

Fig. 13*B* shows a similar comparison of installed costs using a radial substation with transformer rated 5,000/6,250 kva, 34.4/4.16 kv, and four feeders as a base. This smaller substation emphasizes the savings which result when feeder cutover facilities are used.

Wartime Telecommunication
Experience in Hungary

by A. C. KOVATS

These wartime experiences in Hungary offer valuable information when the differences between the telecommunications described and the circumstances there and in North America are taken into consideration. The preparations for and the effects of the war are treated.

IN MARCH 1945 a little group of telephone men struggled through the war-torn streets of Budapest to reach the Hungarian General Post Office building and one of the dial offices of the capital located in the same building. The long and terrible storm of the war was just over. There was no transportation, no electricity, no water or gas supply, and no telephone—only ruins, smoke, dust, dead men, and dead animals everywhere.

The little group started from a distant school building where only a desk, with a tiny sign on it, represented the Post Offices and the telephone and telegraph services. Finally they reached the building. There it stood as a monument of hopeless despair, still smoking, covered with debris. A couple of minutes later the men stared at the remains of the 20,000-capacity dial office, twisted and badly burned, hanging through the collapsed floor. That was the moment when they fully realized how the destructive effect of war had produced a reconstruction problem of almost inconceivable magnitude.

The destruction of the telecommunications system was almost total because the long series of war actions destroyed a large part of the equipment and completely eliminated the organization. The way of reorganization and reconstruction was long and laborious, but it gave much opportunity to review the prewar defense preparations with a view to their effectiveness. It also gave the communications engineer a unique experience and extended his knowledge in a particular field which unfortunately is important in these troubled times. The question is whether it is practicable to utilize this kind of experience, gained in a small European country, for the benefit of the large North American telecommunications system. It is felt that a good part of those experiences can be evaluated in a beneficial way if one is aware of the differences between the two systems and circumstances.

THE COMMUNICATIONS SYSTEM BEFORE THE WAR

Organization. The Hungarian telephone and telegraph system was owned and maintained by the state and together with the postal services was under the jurisdiction of the Minister of Commerce and Communication. The whole organization was controlled by a large department of this ministry called General Management of the Post Offices. The department consisted of sections such as Personnel, Finance, Telephone and Telegraph and Radio, Operation and Business, Vehicles, Architecture, and sections for the postal services. This department ordered the telephone, telegraph, and radio equipment from various manufacturing companies of the Hungarian telecommunications industry, which was well developed and carried on a considerable export business as well.

The maintenance of communications system was decentralized. Six district managements, located in the most important cities of their districts, controlled the erection and maintenance of outside plant and office equipment and cared for traffic and operation as well. There was a Central Material Depot and Repair Shop in the capital which fed the decentralized district depots and made those repairs which were too extensive or complex for the district shops. Research Institute and a large plant called Central Garage and Repair Shop for vehicles completed the instrumentalities for plant construction and maintenance.

Plant and Development. During the period prior to the beginning of the war in 1939, the country was just recovering from the economic crisis of the early 30's. After this serious setback the development of the communications system started again, aiming to increase the capacity and efficiency to satisfy growing requirements. The emphasis was laid on an increasing application of automatic switching in both local and toll service and on modern transmission facilities. As a result of traffic and transmission studies the realization of a toll centering and toll routing plan was underway. A number of the toll centers had been provided with dial offices and with modern toll switchboards. One of the toll centers had been equipped with a cordless toll board. The toll service was gradually pushed toward the combined line and recording method and operator toll dialing with pad control and the first steps had been taken toward subscriber toll dialing with automatic ticketing in the interarea service. Plans for solving the problem of improving service to the extensive rural areas were also being developed through use of automatic and semiautomatic rural and selective party-line systems rather than the common control-type rotary systems applied in cities and industrial towns.

Development of the outside plant and transmission facilities was in agreement with the toll centering and routing plan and with the recommendations of the Comité Consultatif International Téléphonique. Regrouping of the

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trunk network and realization of a proper transmission-loss distribution started on routes with high traffic density. A number of open-wire and cable-carrier systems were employed and carrier entrance cables were constructed. Besides the extension of existing toll-cable facilities, a new nonloaded toll cable was being built toward the industrially important northeast.

The pace of the telegraph system's development was a little less rapid due to the moderate pressure of demand. However, extensive use of the voice-frequency carrier-telegraph system was initiated and teletypewriter systems started to take over the field from the old Morse and Hughes systems. Study and preparations had been made for an automatic telegraph central-office system as well.

As a result of this development effort, the damage of the depression years was repaired. The promising development of the communications system was in full progress when the ominous clouds of the approaching storm started to overshadow all the plans and accomplishments.

EFFECTS OF THE CRITICAL POLITICAL SITUATION

Organization and Administrative Changes. The sudden worsening of the political situation did not find the system prepared to effect a quick transformation from peace to war conditions. The change happened under the pressure of circumstances. New viewpoints in design, development, and service started to influence the engineers' planning. The general attitude gradually became safety and defense conscious. This was reflected in organization changes as well. A military representative was delegated to the General Management as a liaison officer of the Ministry of Defense. Also, with regard to the growing number of special projects and operational and personnel problems, a separate section of the General Management was formed to cover all defense efforts. Special security measures were necessarily introduced such as personnel assignments to defense work, confidential handling, routing, and storing all papers covering defense plans. Extraordinary administrative routines and arrangements were made to facilitate the rush handling of defense works.

Shortages. Other factors, which required considerable rearrangement in planning and in business policy, were the growing shortage in basic raw materials and the lack of free industrial capacity, both primarily due to the rearmament effort. All work items and projects were classified on the basis of their importance and urgency from the war economy's viewpoint. This priority list became a significant factor because the materials necessary for manufacturing were allotted to industry in accordance with the priority list. The communications industry was forced to use new materials in lieu of scarce or precious ones. All such propositions had to be thoroughly investigated before approval. There were special administrative arrangements set up to accept individual bay equipments rather than completed offices in order to diminish the curbing effect of rising prices and to provide the industry money to facilitate early and safe purchasing of materials.

These are only a few examples to illustrate how the engineering manpower was more and more diverted from its original purpose and how the engineering effort applied to technical development had to be continually reduced as requirements for defense preparations increased. All these measures changed the normal setup very much and slowly the defense measures and considerations became dominant factors in almost every technical decision and the real effort of the administration was aimed at one goal which was readiness for an emergency.

PREPARATIONS FOR EMERGENCY

Continuation of Service. A country's extensive and complex communications system produces a multitude of sensitive spots to be protected and to be prepared for an emergency. The task of preparation was further complicated by the special requirements of various authorities and organizations. The most urgent thing appeared to be to satisfy the requirements of the military and civil air defense and to protect the plant against heavy destruction and long interruptions of vital services.

Realizing that communication has a great importance in an emergency, the problem of continuity of service was given top priority. It was obvious that during an air-raid alarm or under an emergency that might result, a full-capacity toll service would be quite impossible. On the other hand a minimum-service requirement must be satisfied under all circumstances. This minimum-service requirement is defined by the probable traffic originated by a very limited number of the most important military, governmental, and public service stations. In order to meet this requirement extensive preparatory work had to be done.

Emergency Systems. First a detailed survey was made in order to decide upon the number and location of stations to be serviced during an emergency and the routes and load of the anticipated traffic. These data facilitated the correct planning of the emergency system. Components of this system had to be adequately protected. The most radical protection was to put all emergency means underground, including important subscriber stations. A number of these emergency stations had been installed in shelter rooms preferably together with the transfer keys in order to draw the emergency installation into day-by-day usage.

Trunks were selected for the emergency network using existing cables, otherwise new cables had to be laid for this purpose. In order to derive the prepared emergency network from the regular one at any time and as quickly as possible a safe multiswitch was required which could be directly attached to the cable without endangering its insulation. A knife-type multiswitch with waterproof encasement was developed for this purpose. This type of multicontact transfer switch was considered as the most advantageous device to be mounted in cable vaults or, if necessary, in manholes.

Much concern was felt because of cable ducts on bridges and in certain cases a by-pass submarine route or, as in Budapest, submarine and tunnel routes were established. As a further measure reserve cables were ordered and stored for those cable sections on bridges which were considered as critical ones.

Emergency offices were installed in every important

telephone office building to handle emergency traffic during the air-raid warning period. It had been decided that, except for a few special trunk groups, ringdown manual operation was the most favorable with respect to its insensibility, reliability, and trunk efficiency. The majority of the emergency switchboards could serve both local and common battery stations.

These offices were usually placed in a shelter room of the office building and were reinforced with additional supporting beams and poles with braces as a protection against collapse. In some places, where the size of the emergency office or the number of its toll terminal and transmission equipments and the size of the power plant necessitated, a separate thick iron-reinforced concrete-block building was constructed to house the emergency office and its equipment.

Whenever it was possible, the emergency office was placed near the cable vault of the office building. This was done to avoid difficulties in changing the tracing of toll cables due to the compensation troubles in connection with the change in cable length and to facilitate switching the outside plant from the regular to the emergency office.

Special attention was paid to the emergency communications requirements of the capital with regard to the numerous important governmental and other offices and to the fact that the capital's toll office was the national center collecting all the most important national and international lines and having access to all toll group centers.

Considering the importance of an emergency office which could be called the national emergency office, the decision that this should not be installed in any building but located in a place which was absolutely safe and yet not far from the communications center, appeared to be logical. An ideal location for the national emergency office was prepared by tunneling into one of the small mountains of the capital. The large artificial cave which housed the office could be reached through blast- and gasproof tunnels. Air pressure above atmospheric was maintained in the whole establishment. The office consisted of more than one floor and had its own power plant and air-conditioning system. A combined emergency toll and local office and telegraph center was installed with all necessary toll terminal and transmission equipment. The switchboard was able to service considerable toll traffic including toll connecting traffic towards the capital's local system. A number of important stations, some of them in shelters, had direct underground connections to the emergency switchboard in order to obtain special and safe toll and local service. This so-called *B* office had permanent underground cable connections to the national toll office and, by means of emergency multiswitches, selected intertoll trunks of the main routes could be switched to the *B* office by-passing their normal routes toward the national toll office.

To facilitate good maintenance of the equipment and proper training for the personnel assigned, the *B* office was kept in operation with its partial capacity from the time its equipment had been completed. As it was very fully equipped and had reserve materials and piece parts in its storeroom, this was considered as a kind of emergency stock.

Ground Observers' Network. The *B* office had another important role serving the headquarters of the civil-air-defense organization. This was the place to which the calls of the ground observers were switched and where the air-raid warning, broadcast through one of the transmitters of Budapest, was originated.

Establishment of the ground observers' network was one of the most significant defense jobs. This, partly utilizing the existing toll plant, was to connect the observers' stations to air defense centers of the alarm area by means of automatic line-switching devices. These switching devices made it possible to by-pass toll offices, when using preassigned toll lines for the emergency connections. They could be operated by either the observers or the headquarters' staff. All lines used for this purpose were improved electrically (splices, insulators, fuses, etc.) as well as mechanically (mountings, poles, etc.), and to facilitate periodical check and the location of faults these lines were marked throughout their length (colored stripes on the insulators, etc.).

Miscellaneous Preparatory Measures. Besides the establishment of the emergency and ground observers' networks, the defense preparations affected the whole plant and the training and organization as well to achieve considerable protection for the communications system. The office-equipment protection necessitated a great variety of additional equipment and special constructions such as blastproof and fragmentproof window protection, blast-deflecting walls, additional wall and ceiling supports, fire extinguishers, mains, independent emergency light networks fed by the office batteries, various blackout utilities, elimination of all combustible material from the attics, and impregnation of the roof constructions against fire. Special attention had been paid to the safety of the cable vaults, power plants, and fuel storage, and to the appropriate storing of spare parts and tools. In towns, entrance cables replaced open-wire lines around central office buildings within a 500-yard radius.

In the case of the toll-dialing equipment and cordless switchboard, the general feeling was that those equipments are less elastic when—due to uncontrollable circumstances—sudden traffic changes or regrouping of trunks become necessary. Thus, transfer arrangements were prepared to facilitate a change in method of operation.

The necessity of a number of mobile emergency office units was realized. A mobile unit should consist of an emergency switchboard with distributing equipment, a minimum amount of toll-terminal equipment such as line coils, simple repeaters with by-pass signaling equipment, and possibly short-haul single-channel carrier terminal equipment. To provide a versatile and useful mobile emergency office unit, considerable planning and experience were required. Unfortunately much progress could not be made due to the unexpectedly rapid developments and deterioration of the over-all situation.

It was assumed that the dial offices would function during any emergency. However it has to be realized that the operation of a dial office can be indirectly paralyzed by a major and lengthy commercial power breakdown caused by damage to power cable or equipment. Therefore, emphasis was laid on good maintenance of the power plants including

diesel motor generators, and more mobile battery-charging units were ordered.

Office personnel had been trained to walk down to shelter rooms without forgetting to take with them maps, documents, and other papers which were too important to be lost. Papers of this kind were not to be piled up on anybody's desk and every person had a small fiber emergency suitcase for such papers. Operators and maintenance people were trained in handling emergency offices, and new priority regulations were issued including screening calls for areas affected by emergency.

The number of mobile repair groups was increased and emphasis was laid on fast report of damage. The repair groups were reasonably dispersed and so was the material reserve. As an example the cable fault locator and repair group, which formerly was concentrated in the capital's "Cable Office," was dispersed by being attached to the district managements. Also, the repair groups had been made more mobile by assignment of additional automobiles and small trucks. The material reserve consisted mostly of outside plant and station materials and switchboards. The major part of the reserve switchboard equipment was displaced boards originally used in formerly manual offices.

Arrangements were made to remove manufactured equipment from the factories as soon as possible and to store them safely on the site of later installation to disperse material. Dial office equipment could not be piled up as reserve stock because of the growing limitation of industrial capacity. It was hoped that in case of a sudden equipment loss, dial-office equipment in manufacturing process could be used as replacement.

EFFECTS OF THE WAR

The Human Element. After such extensive preparations it was expected that no effects of the war could produce real difficulties but, as usually happens, reality differed from things anticipated. This was because the human element was neglected in the technical considerations and because calculations and preparations were made without seeing clearly the forthcoming events of the war. Speaking of the human element, one thing learned which should not be left out of any future calculation was the fatigue and drop in efficiency due to the great increase in both job and personal responsibilities and worries and due to the morale-disintegrating effect of direct war actions.

Load of Superimposed Systems. There was another factor which also curbed the efficiency of the communications system and this was the unexpected high load of superimposed systems. Besides the afore-mentioned ground observers' system, the warning (siren) system, Civil-Defense-Organization system, and several military communications systems were superimposed and the number of them was constantly increasing. This, of course, impaired the capacity of the basic communications system and at the same time made it more complex and sensitive. A great part of the long-haul special connections made use of carrier equipment, consequently additional effort was required to make appropriate transpositions on the lines, to install filters, repeaters, channel terminal equipment, and power supplies. The increased application of carrier equipment raised quality requirements toward the outside plant maintenance. Most of these special military projects were unexpected and as a result they had to be completed promptly.

The growing complexity of the system and the urgency of special jobs necessitated a number of highly qualified experts with practical experience in the higher administrative level as well and the contact between high-level administration and the low-level service, which carried out the job, necessarily became very close.

Air Raids. Air raids did not cause much destruction to office equipment but, where there was a hit, fire, dust, and pulverized glass were the most destructive factors. The outside plant suffered more during air raids, but mobile repair groups always mastered the situation, sometimes with improvised temporary lines for an immediate restoration of vital connections. In these cases, even when alternate routes were at hand, the normal flow of traffic was obstructed and only screened traffic could be maintained until the damaged section had been reconstructed.

Another harmful effect of the air raids was a general slowdown in planning, administration, and work. During the prewarning period, as well as during the air raid, all work ceased and only returned to normal sometime after the all-clear signal. People were seeking news and many of them wanted to reach their families despite a regulation which dictated that telephones must not be used for private business during the first hour after an all-clear signal had been sounded. This revealed another weakness of the system which had to be cured, because, due to the immense overload of the coinciding calls, the whole local system became completely blocked after an air raid. A drastic but good solution appeared to be the exclusion of complete blocks of less important stations.

Ground Fighting. When the war reached the countryside, the devastation caused by lengthy ground fighting was experienced. This was the period when the communications system suffered the most. The long fighting practically eradicated the communications system in many communities. Maintenance and repair work stood still and the central offices stopped working because the commercial power supply failed. Most of the cables were damaged or completely disrupted in many places. In the capital several dial offices and the national toll office burned out completely. (The emergency *B* office had not been damaged during the entire fighting.) The same happened in the country in several places. Equipments like repeaters, telephone and telegraph carriers, teletypewriters, station equipment, and even full dial offices were removed by the enemy fighting forces. Heroic maintenance crews kept offices operating till the last moment, but it remains an open question whether it was good or not because the enemy, when infiltrating in a certain office area, used the telephone for reconnaissance purposes by forcing subscribers to call friends living in areas still under control.

During the major ground fighting there was not much to do. When the fighting was over, the first thing to be done was to re-establish some organization to clear up the con-

dition of the system and to improvise the most necessary connections using every available means. Everything else is a matter of correct planning to facilitate quick and successful reconstruction.

CONCLUSION

To PREPARE a whole communications system for emergency is a very extensive and complex task, and although it cannot be completed to cover all the possible conditions which may arise, it would be even worse not having done anything at the time when there is no pressure and no shortage. The emergency preparation is a never-ending job. Even if the whole emergency system were established, new installations, plant extensions, or new systems developments necessitate adjustments and additions to the emergency layout.

Organization, Training, Personnel. Looking back to past experience, it is felt that a small but effective department should be permanently available in every system's administration, fully responsible for proper emergency measures. It is justified because of the considerable costs of the emergency preparations and because emergency viewpoints may easily be forgotten or neglected under the pressure of the daily engineering and traffic problems. Late or unsatisfactory measures always cost more in the long run. Therefore, the expense of a separate group of people caring for this very important need will be repaid.

It would be a great error to consider the emergency problem from a purely technical angle. Personnel problems are equally important because, under extraordinary circumstances, the human element plays a very great role. Proper training is very important. The training should be as practical as possible. This holds even for higher level administration who should also be able to give practical direction without delay in case of rush installations, sudden problems, or any technical difficulties.

During the emergency, there is little time for study and paper work. The training should also be extended to familiarize people with the location and the layout of plants or equipment considered as critical. One can decide more easily and can help a lot more by being familiar with the spot affected. Another significant factor in dealing with personnel problems is the formation of an adequate reserve of well-trained personnel. Allowance must be made for military call-ups and for casualties due to air raids, in other words for a higher per cent of fall out. The emergency service must not be paralyzed by lack of well-trained personnel.

Proper emergency organization should think of many details, sometimes seemingly insignificant ones. For instance, the situation may arise where one can save time, the most important element in an emergency, by prearranging definite places for people to report after unexpected or devastating events. Much annoyance resulted in certain cases from cable plans or plans for distributing frames being missing. These and similar details should be considered and regulated in time.

Dispersion of Equipment. The principles and layout to be employed in an emergency system cannot be planned and carried out in a uniform way without considering the individual plant requirements. Measures considered to be adequate for one area are not necessarily satisfactory for another more critical one. The nature of danger expected should also be considered. Dispersion of a system may be expensive, therefore the limits and the effects of the dispersion must be taken into account. Any splitting of trunk groups means less trunk efficiency in the long run. On the other hand, too large and too concentrated toll exchanges cannot be recommended since they are very vulnerable. Efficient up-to-date tandem arrangements and reasonable compromise may help in finding correct solutions.

Experience taught that repeater stations for toll-cable facilities should not be concentrated. Before the war, there was a trend to build a repeater station of considerable size and to terminate all the toll cables there. This is a very vulnerable layout and should be avoided. It appeared to be reasonable to go even further and to disperse toll-terminal equipment as well.

Diversity of Means and Routes. Diversity of facilities and of routes between important terminals of the communications system is a very useful feature. This was missed very much but there was not enough time to take full advantage of this kind of arrangement. Microwave connections with entrance cable are desirable but should not be considered as the only link between toll centers. The diversity of routes is an inevitable requirement for any emergency system even if the routes are not far from each other. A good example of this was the reliability of the split unloaded cable.

Emergency Offices. How many emergency offices should be employed for a city and of what size depends on local circumstances. Too many switching points are not advantageous. Manual ringdown operation is a major feature in any emergency system which should not be completely abandoned even for the most attractive up-to-date automatic system.

In the case where a dial office had been badly damaged or destroyed, use had been made of private-branch-exchange equipment or part of an intact dial office and also of crated and stored dial-office bays which originally were intended for a less important office and were piled up there for later installation to establish emergency service. Another emergency measure, applied in such cases, was the distribution of important subscriber lines among the surrounding office areas using existing interoffice trunk cables. Mobile emergency office units should be at hand in adequate number. They provide good service, bridging the first period after a disaster, until something can be done on a more permanent basis.

Restoration. The importance of dispersing reserve material for the outside plant and of highly mobilized dispersed repair groups cannot be overemphasized. Quick restoration can be facilitated by employing a strong type of drop wire with good insulation; it was used in great quantities.

Trouble shooting and restoration of damaged equipment is often hindered by ruins, debris, etc. Mobile machinery for cleaning up debris quickly must be at hand for the emergency service.

Incremental Cost of Power Delivered Computer

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THE integrated Southern Company System, consisting of Alabama Power Company, Georgia Power Company, Gulf Power Company, and Mississippi Power Company, has had in operation an "incremental cost of power delivered" computer since June 1954. This analogue type of computer quickly determines the incremental percentage of power delivered from each source, as selected, and simultaneously calculates the incremental cost of power delivered from any particular generator.

The operation of the computer is relatively simple, as the operator merely pushes the button corresponding to a particular generator; and then the computer automatically displays the incremental percentage of power delivered from that source, and the incremental cost of power delivered from that generator to the load centers.

The only information required from the power system for computing the incremental transmission loss is the magnitude of the power at each of the sources. In the case of tie lines, both magnitude and direction of power flow are required since power may flow in either direction. Large industrial loads which do not conform to the normal load pattern are introduced into the computer as sources of negative generation. The magnitudes of the power in the sources which are subject to rapid or unpredictable variations are fed into the computer automatically by retransmitting means in the telemetering receiving recorders. The megawatt values of the sources which are not fed in automatically are set by manual dials according to information received on the Teletype equipment.

The computer has been built to accomodate 30 sources although at the present time only 23 sources are required to represent the system. In some instances, a source may be made up of several generating stations which are in close proximity, or it may consist of a generating station, a nonconforming load, and a tie line to an adjacent system. The computer is integrated into system operation so as to realize, as nearly as is practicable, equal values of incremental cost of delivered power for all the generating units.

Besides its basic function of determining the incremental cost of delivered power, the computer may also be used for obtaining a more realistic evaluation of transmission losses when making short- or long-term contracts for the sale of power to neighboring systems.

The mathematical expressions handled by the computer are as follows:

1. Expression for incremental transmission loss

$$\frac{\partial P_L}{\partial P_m}=2\sum_{n=1}^{s}B_{mn}P_n+B_{mo}$$

Where s = number of sources; m = row index which assumes all values of whole numbers from one to s; n = column index which assumes all values of whole numbers from one to s; P_m = power source m; P_n = power source n; P_L = total transmission loss; B_{mn} = constants determined by the system characteristics; and B_{mo} = a constant based on the incremental transmission loss at zero system generation.

2. Expression for incremental generating cost

$$\frac{dF}{dP}=(b+2cP)f$$

Where b and c = constants applying to a particular generator; P = kilowatt output of generator; and f = cost per million Btu's.

3. Expression for incremental cost of delivered power

$$\lambda=\frac{\dfrac{dF}{dP}}{1-\dfrac{\partial P_L}{\partial P_m}}$$

Where λ = incremental cost of delivered power in mills per kilowatt-hour.

The computer is of the semiautomatic type and the computed information, i.e., the required generation change, is dispatched by means of the Teletype channels to the generating stations. The underlying principles are such that they can be conveniently adapted to load the power system automatically on the basis of incremental costs of delivered power in conjunction with recognized forms of load-frequency control.

All of the circuits operate directly from the 115-volt 60-cycle single-phase power supply; the power requirements being in the order of 250 watts. The accuracy of the computer is not affected by voltage or frequency variations normally encountered on electric systems.

The computer has fully lived up to all expectations. The power co-ordinators are enthusiastic about it, because as the system load changes, they can quickly determine at what plants generation should be increased or decreased and the amount of such change. Prior to the use of this equipment, considerable difficulty was experienced during the morning loading and evening unloading period. When the loading of the plants is determined by the computer for equal incremental cost of power delivered, no difficulty is experienced from overloading of transmission lines. Savings in power production expenses being realized from the co-ordination of incremental production expenses and incremental transmission losses were estimated at not less than $200,000 a year for the system.

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Human Resources in the Technological Future

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New technology and new technological applications will be necessary to provide the equipment and techniques required to produce the new and better consumer goods envisioned for the future—and this new technology is going to change, as well as increase, the requirements for more broadly trained technical talent.

WITHOUT DOUBT, there is almost unanimous agreement on two points concerning the technological future: first, that it is a bright and exciting one; and second, that it is a special challenge to those who are concerned with the efficient production, distribution, and use of electric power.

However, probably not nearly so united a front would be presented if one were asked to rank honestly, in the order of the active attention devoted to them, the five resources needed to meet that challenge: time, money, facilities, men, and materials. It is evident from experience that one's interest tends to shift about among these resources as specialized problems push one or another forward with an urgent claim for attention. This type of thing cannot be avoided, particularly on the short-range basis; but manpower must be the pre-eminent concern on both the immediate short-range and the future long-range bases. If manpower is not ranked at the top of the list there is great room for doubt whether the engineer's particular facet of the future is going to be as bright as he may imagine, or his challenge as fully met.

This article will examine some of the forces which are acting to increase the importance of manpower, and in particular, technically trained manpower. Everyone is aware of the great need all business faces to develop leaders skilled in the management arts; the concepts and plans which outstanding thinkers in these fields are making are exceedingly stimulating and reassuring. These will not be dealt with here, but rather the concepts and plans required to develop the technical talent to meet first the immediate and the continuing technical challenge. Of course, engineering must furnish the necessary and proper quota of candidates for managerial work, but this article will be confined to the problem of getting the technical work done.

The fundamental force acting to put a premium on technically trained manpower is the tremendous rate at which technology is growing—both in volume and in complexity. Also acting in the same direction, of course, is the enormous size of the job that has been laid out. It seems apparent that if the power, the capital goods, the improved industrial techniques, and the shower of new and better consumer goods are to be provided, new technology and new technological applications are going to be the principal factors in these calculations. And this new technology is going to change radically, as well as increase, the requirements for technical talent.

Essentially full text of an address presented before the American Power Conference, Chicago, Ill., March 31, 1955.

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THE IMPACT OF TECHNOLOGY

EXAMINE, first, some of the impact of technology; it is convenient to do so in terms of the resources, other than manpower, required to run a business. Consider the resource of materials. Today, in sharp contrast with a yesterday not too far past, the principal limitation in many products is not the state of the art on which they are based, nor the lack of a use-demand which would justify improvement, but a roadblock in the performance characteristics of materials. Insulations, structural metals, magnetic materials—all are being worked, in the most advanced products, at or near one or another of their physical limits. This means that progress in such products as jet engines, prime movers, generation and distribution equipment, and most of the glamorous semiconductor applications, will depend on the erudite technologies involved in the improvement of materials and on the delicate and complex relationships by which these improvements are incorporated into new customer-desired products. It should be noticed particularly in this connection that the requirements of this task differ sharply from the kind of competence customarily looked for in new recruits to the electrical industry.

Consider the business resources of time and money. The expense levels which nowadays must be factored into any change of product design or method of manufacture are so high as to be, on occasion, an effective bar to progress. As a fortunate offsetting factor, the demands of proper timing in today's competitive economy are increasing for the manufacturer who wishes to grow. The result of these two factors is an increasing demand for improved products, but with increasingly high guarantees of feasibility and probability of success. Interpreted technologically, this means that technical work must have a much lower degree of empiricism than in the past. While the spirit of willingness to take a chance is certainly not moribund, the method of cut and try can be afforded only in the most unusual cases.

Since not more than a minimum of the empirical approach can be employed, it is obvious that the technological

aspects of design and product planning are going to require a great deal of advance technical work of highly theoretical, yet painstaking and detailed nature. While some of this work is repetitive rather than creative, and can be delegated to machines, the role of the technically trained man is nevertheless increased, not diminished in importance.

To consider the business resource of facilities, take the fascinating subject of automation. If the imagination is given free rein, some idea can be gained of the technological content in the job of designing, building, and maintaining the specialized machines which will go into the automatic factory. But the most important point of all must not be overlooked: the necessity of designing products specifically for manufacture by automation techniques. Customer-desired products must be created with the capabilities of automation in mind; then the original design must be appraised by the automation experts; and a 2-way process of mutual modification must take place. This means again the use of extremely erudite technologies and exceedingly complex relationships among the technically trained men who create the products, who create the machines to build the products, and who create the markets for the products.

These brief examples indicate how technology is going to be an increasingly important and complicated factor in the engineer's efforts to bring the future he envisions into existence. Are the requirements for technically trained people showing any parallel developments? Undoubtedly they are. Today, in the author's company, one out of every 15 employees is a technically trained man. This ratio is expected to go on increasing in the future; and this has caused the company to examine its requirements, to try to write concise specifications covering its needs, and to make clear-cut plans for filling them. The following are some of the results and the implications of those results, which seem to have high significance for all. They fall into two broad groups: those centering around quality, and those focusing on quantity of available manpower.

THE QUESTION OF QUALITY

Turning to quality, the technology itself should be examined as a background for determining requirements. The growth of new technology, starting with the impetus of World War II and continuing since, has been almost geometrically explosive. The volume of technical literature related to a given field of specialization is tremendous and the complexity of much of its subject matter is extremely high. There is a good description of this situation in a 4-line stanza, of which the first two lines were written by Alexander Pope in honor of Sir Isaac Newton. The last two lines were added by an exasperated modern poet.

> "Nature and Nature's laws lay hid in night.
> God said 'Let Newton be,' and all was light!
> It did not last. The Devil, howling 'Ho!'
> 'Let Einstein be!' restored the status quo."

The first implication in this situation is that complexity may have infiltrated further than has been suspected and is a consideration in many present problems, not to mention future ones. In specific terms, it would seem that many elements of today's technical work completely justify the greater experience and the training in depth possessed by men who hold a doctor of philosophy or equivalent degree in mathematics or the basic sciences. These elements, however, are still being assigned to people whose qualifications are something less. Certainly their efforts are deserving of high praise, but is the wisdom of this decision equally deserving? This practice has produced some gallant struggles and eventually satisfactory results, but it has on occasion cost dearly in time, lost motion, and over-all quality of performance.

A second implication is that, in view of the increasing volume and complexity of technology, the great number of younger recruits who come to industry from the technical schools are best prepared for the work awaiting them if they are trained broadly rather than specifically. Yesterday's technological advance may render today's engineering practice obsolete, in whole or in significant part, and new technology must be incorporated into revised engineering practice. Experience shows that the best background for this ability is broad training in fundamental principles of mathematics and of the sciences, and in creative approaches to problem solving rather than problem solving itself; the graduate so trained is not nearly so liable to be left behind with a bundle of obsolete practices while the technological cat has leaped ahead in some new direction.

The third implication is that for engineers, as well as others, "No man is an island." As the technological content of the engineer's work becomes more and more difficult, more and more abstruse, and therefore more of a problem for his associates in other fields to grasp, the need for understanding to be coupled with knowledge becomes imperative. The engineer must understand his fellow men and be able to make himself understood by them. Therefore, in addition to broad training in mathematics and the physical sciences, this work requires young men who have been educated in the humanities, the social sciences, and in the communication of ideas.

Industry has a great obligation to be articulate about these requirements, so that the colleges can gain understanding of how industry interprets its needs. This has led to discussions with many educational leaders, and it is most encouraging to find them equally inclined to do some soul-searching and reappraisal of their objectives. It is also gratifying that they welcome from industry—as interested parties in the future achievement of their graduates—continuing counsel to incorporate changes in requirements as they crystallize.

To reflect the keen recognition by education of this situation, the following is a very apt statement of the problem and of the creative approach to its solution, made by Dr. Lee A. DuBridge, president of the California Institute of Technology, before the International Electrotechnical Commission in Philadelphia, Pa., in September 1954:

"During the early days of World War II a new invention of great use in warfare was made—radar. Electrical engineers were needed to help develop new kinds of radar equipment—new circuits for higher frequencies than had heretofore been used. But electrical engineers were

stumped by the problems of the transmission of centimeter waves. 'It is quite straightforward,' said the physicists. 'Just use Maxwell's equations.'

"But Maxwell's equations—on which all of electrical technology was based—were not familiar to the electrical technologist of 1941. This was natural. The engineer had learned simpler rules which handled most practical problems dealing with low-frequency circuits. But when a new frequency region was encountered, one had to return to the basic physics of the problem, to Maxwell's equations. Hence the chief contributors to the advancement of the microwave radio art in the early war years were the physicists. Today of course, 13 years later, microwave circuits are part of the well-known lore of the modern radio engineer.

"Maxwell's fundamental equations provide the basis for several branches of electrical technology, each branch having superficially quite different engineering practices. This is the reason that the more forward-looking engineering colleges are increasing their emphasis on fundamental principles of physics, even at some sacrifice of practical experience with currently useful machines, devices, and equipment. Sooner or later the engineer working in a frontier field will have to return to basic principles to solve a new problem . . ."

THE QUANTITY REQUIREMENTS

FINALLY, there is the quantity aspect of the manpower situation. The present requirement at General Electric is one technically trained man for every 15 employees, and this is expected to increase. What are the chances of attaining an increase? This question merits close scrutiny.

In common with other concerns which need large numbers of trained people, the company has known for some time that in spite of compulsory education through at least part of the secondary curriculum, and in spite of the constantly widening availability of a college education, a large number of the right people fail to emerge as college graduates. This fact is generally true; and its significance with respect to technical fields of endeavor is high. The recent work of the Commission on Human Resources and Specialized Training has added a great deal to the specific knowledge in these matters and has given strong emphasis to the problems.[1]

The Commission's figures show that when the total population is ranked according to native ability, as measured by intelligence or Army General Classification test techniques, an alarming number of the top 10 per cent do not go on to, or complete, college work. Only 42 per cent of this upper tenth are graduated from college; in other words, 58 per cent of the best potential talent is lost to those fields where a college degree is generally necessary for entrance. Considering the field of engineering specifically, there is a still greater challenge. As might be expected, engineering attracts a group of people whose average ability is substantially higher than the average of the population as a whole. In point of fact, if all engineering graduates are ranked in native ability according to the Army General Classification Tests, almost the entire upper half of engineers come from the upper 10 per cent of the population in ability—the region where there is 58-per-cent attrition in the completion of a college course. The median test score for all engineering graduates is a test score of 124; the upper tenth of the population distribution curve starts at 126.

Of course, the rising birth rate is due to flood the primary and secondary school systems, and this will mean that, in due time, a corresponding increase can be expected in the total number of engineering graduates. However, a corresponding expansion also can be expected in total manpower requirements; the need for a high proportion of technically trained people will not be satisfied by a mere increase in totals. In short, the country is heading toward not only an expanded economy, but toward an everyday life in which technology is an increasingly important factor. Therefore, a higher proportion of technically trained people will be needed in the work force, and this cannot be expected to happen unless something out of the ordinary is done about it.

The Commission's studies point up the fact that the big loss occurs between high school and college, a circumstance which many in industry have been working to correct for a number of years. At the author's company, both national and local programs of working with secondary schools to awaken and maintain interest in going on to college and in preparing for a technical career have been successful in the past. It is recognized that anything that can be done to increase the effectiveness of these efforts will be particularly worth while. Of special interest to industry is one conclusion of the Commission. While there are a number of causes assigned for failure to go on to college—causes such as economic ability, racial influences, and the like—the greatest single apparent cause is lack of motivation. "Lack of motivation" is a general term, but its principal meaning seems to be that there is no interest or incentive in the family background, even though it may be a well-to-do one, toward going on to college—and no substitute provided in the secondary school.

The techniques of motivating people are surely not unfamiliar to industry, which is well accustomed to bidding for public favor in the market place, and it should be encouraged by this opportunity to increase its efforts with the secondary schools. In the the author's company, there are long-established programs such as educational aids designed for secondary schools, and summer school programs for high-school teachers, which it is hoped will be broadened in scope and heightened in effect.

Feasibility and good probability of success have been established; for example, in one instance a special campaign to present technical job opportunities in a particular plant community materially increased enrollment in secondary school subjects necessary to an engineering college preparatory course or to a technical vocational course. Many firms and many individuals are cognizant of, and working continually to solve, this problem, but it seems clear that, as a nation, a still broader base is needed for this kind of effort.

If the manpower problem is not solved, we shall certainly flounder for lack of people, both people trained in breadth and people trained in depth, who are competent to per-

ceive, attack, and solve the technological problems leading to the future toward which all are striving.

The need is an urgent one, as emphasized by some significant statements made by the chairman of the Research and Development Committee of the Joint Committee on Atomic Energy in August 1954. The following is quoted from a speech by Representative Carl Hinshaw of California:

"Our educational program is geared to produce college graduates in large numbers, but beyond that—what?... What do we do about breeding scientists—men who are inspired to learn beyond the mere practical, into the very secrets of nature. We think of Einstein, Fermi, Teller, Wigner, Rabi, and many more—all trained abroad. And then we do have a few Americans, such as Lawrence... and DuBridge. But we need desperately to train more young scientists in order to obtain a few truly great ones. What are we doing about it? Do we really appreciate the tremendous dependence of our nation on the scientists and engineers? Do we fully realize that one man with an idea on how to guide an intercontinental missile to its target with accuracy is worth thousands of men in uniform? Instead of concentrating on boastful pride in things accomplished, more time should be spent pondering the magnitude of the tasks that lie ahead and the ways of attracting young minds to attacking these problems.

"As the nations of the world come to depend more and more on scientific progress for their social, political, economic, and military strength, the role of a relatively small number of men and women increases. I cannot stress this too much. No matter to what field we turn—medicine, agriculture, power, or weapons—it is not the great numbers that count, but the few great ideas and the great brains that developed them. And there are always too few people with trained minds to carry us forward. We are too quick to oppose the idea that one man can make a more significant contribution than another. The concept that all men are created equal has dominated our thinking. To be sure, they are equal before the law. But they are not all alike. Men cannot be treated like so many cars coming off the assembly line. The success or failure of each man and woman in making his contribution to the world is a matter of emphasizing particular talents, or being different each in his own way."

THE TECHNOLOGICAL FUTURE

NEW TECHNOLOGY is destined to have a predominant influence on all the resources required to run a business; on time and money, on materials, on facilities, and most of all upon manpower. The industry must concern itself with the quality and the quantity of that manpower in the immediate present, and it will also be a continuing concern. Much will be required of the engineer in his work to build the future he wants and knows is possible. On a day-to-day basis, first one challenge and then another will be flung at the engineering profession, challenges which will need statesmanship, managerial ability, and great technical skills. The fact should never be lost sight of that all these qualities are qualities of men—and that, in this business, if technical skill is lacking, there will be need of little else.

REFERENCE

1. America's Resources of Specialized Talent, prepared by **Dael Wolfle.** Report of the Commission on Human Resources and Specialized Training, Harper and Brothers, New York, N. Y., 1954.

Improved Experimental Solar Battery

The efficiency of the solar battery produced experimentally by Bell Telephone Laboratories, Inc., has been almost doubled in the 1 year since its announcement, as it has been increased from 6 to 11 per cent—an efficiency comparable to that of the best gasoline engines and more than 20 times higher than that of the best photovoltaic devices available. The improved "cells" or silicon wafers can now be electrically linked together to deliver power from the sun at a rate of up to 100 watts per square yard of silicon surface.

Treatment under gas at high temperatures permits the introduction of minute traces of boron into the atomic structure of the thin slice of arsenic-doped silicon at a precise rate and under carefully controlled conditions, with the boron reaching a depth of less than $^1/_{10,000}$ of an inch. This thin layer and the remainder of the silicon wafer form what is known as a *p-n* junction, the heart of the battery.

Trial models of the improved battery will have their first practical test as part of the telephone system this summer in Americus, Ga., where controlled experiments will determine the usefulness of the battery in supplying power to amplifier stations on rural telephone lines.

A Versatile High-Voltage D-C Insulation Tester

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The high-voltage insulation-resistance meter described in this article provides a rugged, portable, accurate, and convenient means for making d-c overpotential tests or measurements of insulation resistance, polarization index, or leakage current versus voltage.

IN recent years the use of nondestructive d-c tests to measure service deterioration of electric-equipment insulation has shown a marked increase. This has been particularly true in the case of high-voltage apparatus. In this field several types of test, all based on the application of direct potentials, have been used. Measurements of d-c insulation resistance, polarization index (dielectric absorption factor), leakage current at various voltages, and straight overpotential d-c high-potential tests each have their proponents who have reported their findings in the literature from time to time.[1-9]

While there is no general agreement on the optimum type of d-c test, there is concurrence on a number of points:

1. D-c testing will reveal certain faults not observable by a-c tests, and hence may be used to supplement a-c tests in determining insulation quality.
2. Periodic nondestructive d-c tests sometimes make it possible to follow insulation deterioration and to forestall expensive equipment failures by removing the equipment from service before the danger point is reached. This is especially true on high-voltage apparatus, where the prevention of failure is more important because of the basic functions and inherent costliness of high-voltage equipment.
3. The basic requirement for a good program of d-c testing is adequate versatile equipment.
4. To be adequate and versatile, d-c test apparatus must have a highly stable output voltage.

To expand a bit on the first and second points, it is well recognized that d-c measurements of resistance, polarization index, or current versus voltage will often show the presence of isolated conducting paths that are ignored by ionization or power factor measurements. Surface accumulations of dirt and moisture, which are an inherent accompaniment to service, are also detectable by d-c tests. However, to be significant, measurements of d-c insulation resistance, polarization index, and current versus voltage on high-voltage apparatus must be made at the proper voltages. At the higher potential levels, isolated short conducting paths may become electrically joined to produce paths of effectively lowered resistance. Hence, on high-voltage apparatus equipment for d-c testing at voltages up near the operating level is essential. Of course, d-c overpotential tests imply the use of high-voltage equipment. Whatever the test, a high-voltage measuring instrument is required.

To fill this need, the high-voltage insulation-resistance meter shown in Fig. 1 has been developed. While designated as a "resistance meter," any of the well-known d-c tests can be performed with it at any voltage up to 10,000 volts direct current. This meter is a commercial reality. Other meters based on the same design principles with higher maximum voltage ratings have been considered and one with a 75-kv maximum rating is being constructed for use.

DESCRIPTION

THE high-voltage insulation-resistance meter consists of a stabilized source of direct voltage having a continuously adjustable output from 0 to 10,000 volts and an electronic circuit for measuring the leakage current of the insulation being measured. Voltage of either polarity may be obtained. It operates from a 115-volt 60-cycle source, measures 20 by 22 by 15 inches, and weighs about 110 pounds. The circuit is shown in Fig. 2.

When used for d-c overpotential testing it provides a source of test voltage of any magnitude up to 10 kv, practically free from fluctations caused by line-voltage variations. It can also be used to measure insulation resistances to 200,000 megohms at any voltage up to 10 kv, and, of course, polarization index, where the resistance values lie within this range. A panel-type voltmeter and a microammeter from which leakage currents of 0.01 to 100,000 microamperes can be read provide means for current versus voltage measurements.

The direct-voltage source is capable of charging a 0.5-microfarad capacitor in 45 seconds. It is stabilized so that a specimen capacitance of this magnitude will not cause appreciable fluctuation of the microammeter pointer, even when the a-c line voltage changes abruptly within the range of 90 to 135 volts.

The d-c power source consists of a 400-cycle permanent-magnet generator driven by a 115-volt synchronous motor feeding a conventional electronic-tube rectifier and filter. An adjustable autotransformer in the output of the generator permits control of the d-c output.

For measuring resistance or leakage current this voltage

Full text of conference paper CP55-16, "A Versatile High-Voltage D-C Insulation Tester," presented at a session of the AIEE Committee on Instruments and Measurements, AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1955.

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is applied to the specimen being measured through a standard resistor. The voltage developed across this resistor by the specimen leakage current is measured by an electronic-tube voltmeter employing a cathode-follower circuit. This voltmeter is of the inverse-feedback type which minimizes errors caused by differences in tubes. The voltage across the standard resistor is indicated on a panel-type meter having two scales. One scale is calibrated to read resistance directly in megohms at a fixed test voltage level, usually 10 kv. The other scale is calibrated in microamperes. Thus, leakage current can be read directly from this meter at any voltage, or resistance can be calculated from readings of the test voltage and leakage current. This current meter will directly indicate resistances from 8 to 200,000 megohms at 10 kv in four ranges; two additional ranges are provided for resistances below 8 megohms, but for such resistances the test voltage will depend on specimen resistance, and the maximum obtainable will be less than 10 kv. Should the specimen being measured suffer dielectric breakdown or flashover, a protective circuit employing a neon glow lamp protects the microammeter from damage. Thus, even in an overpotential test, leakage current can be determined without fear of the consequences of specimen failure.

The test voltage is obviously of dangerous magnitude. To provide protection to the operator, double gravity-drop safety contactors are provided with connections for electric interlocks. Where conditions permit, the resistance being measured can be placed in an interlocked area. When this is not possible, as when measuring installed apparatus, remotely placed switches can be connected so that personnel handling the leads can close the interlock circuit after they have placed themselves in a safe location. Opening the interlock circuit also operates an internal switch which discharges the filter capacitors and grounds the high-voltage terminal, thereby discharging the capacitance of the sample being measured. On very large apparatus a considerable additional time may be needed to discharge the sample capacitor completely. In such cases it is usual to make an additional discharging connection external to the instrument before disconnecting the high-voltage and measuring leads.

DESIGN CONSIDERATIONS

THE basic requirements for a satisfactory high-voltage d-c test instrument are

1. It should be able to charge the capacitors normally found in large high-voltage apparatus quickly.
2. It should be able to measure the leakage current or resistance of the windings of such apparatus accurately.
3. The direct voltage should be continuously adjustable over its range and remain constant indefinitely at any chosen value.
4. The instrument should be rugged, portable, and easily maintained.

These considerations led to the choice of the motor-generator set, high-voltage rectifier, and filter circuit for the direct-voltage supply.

In order to maintain test voltage indefinitely, d-c power should be derived from an a-c line. However, powering the device from a-c lines makes it necessary to render the d-c output voltage nearly independent of normal fluctuations in a-c line voltage. When measuring apparatus

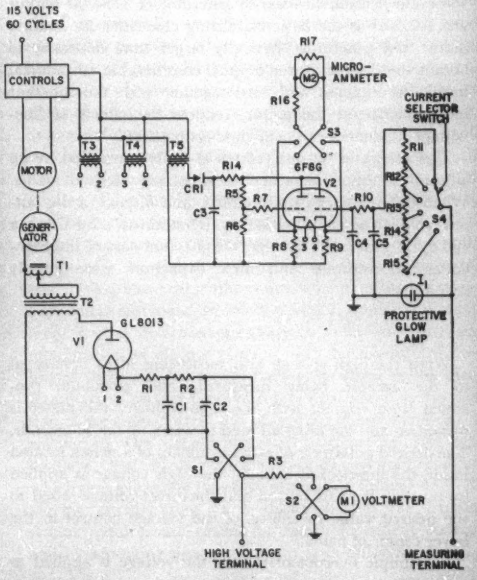


Fig. 1 (above). High-voltage insulation-resistance meter. Fig. 2 (right). Simplified diagram of high-voltage insulation-resistance meter (junction between R_8, R_9, and R_7 is grounded)

which has any considerable capacitance, a fluctuation in direct voltage caused by a change in line voltage will produce a sudden and violent change in the current through the resistance being measured. Such a change results in a wild swinging of the current-measuring-meter needle.

There are two means of overcoming this effect. The less satisfactory solution is to reduce the current-meter sensitivity or damp it highly. The better solution is to stabilize the direct voltage.

In selecting stable direct-voltage sources several types were considered. Direct voltage can be produced by a stabilized r-f oscillator; this requires a considerable number of electronic tubes, which make ruggedness more difficult to achieve, and complicate maintenance. It was also found that stabilization sufficient to permit the desired sensitivity and speed of response could not be readily obtained from such a voltage supply.

An alternative method of obtaining stable direct voltage is that used in the 500-volt General Electric insulation resistance meter.[10] In this instrument 500-volt direct current is obtained by supplying a thyrite bridge circuit with 1,000 volts direct current. Exceptionally good stabilization is obtained from this method and it could be used just as successfully to obtain 10 kv. However, the 20-kv 60-cycle transformer and filter capacitors required are heavy and bulky, and the thyrite bridge also takes up considerable space.

The method selected for this instrument was one which offered all the ruggedness of the thyrite bridge method with less bulk and weight. Relying on the fact that at constant load the speed of a synchronous motor is practically independent of a-c line-voltage fluctuations, a motor-generator set composed of a 115-volt synchronous motor and a 400-cycle permanent-magnet generator of 115-volt output was selected as the basic stabilizing element. By making motor and generator physically larger than necessary to obtain the desired power output, considerable mechanical inertia is obtained and this, together with the inherent independence of the motor, reduces the effects of line-voltage fluctuations to negligible proportions.

The generator output voltage is easily controlled by an adjustable autotransformer to give any desired value. When this is stepped up, rectified, and filtered, a d-c output voltage of great constancy is obtained. By using a 400-cycle generator, the size, weight, and cost of the high-voltage transformer and filter capacitors were greatly reduced.

OPERATION

With the high-voltage and measuring leads connected to the sample being measured, and personnel protected from contact with the high voltage, the meter is turned on and the tubes allowed to warm up for 30 seconds. The desired polarity is selected by means of a switch located inside the interlocked cabinet, the high voltage is applied by pushing the ON button and the direct voltage raised to the desired value by means of the voltage control in the lower center of panel.

For simple overpotential tests the voltage is applied to the specimen for the desired time. When measuring resistance the proper scale is selected by means of the switch at the upper center of the panel. If the selected voltage is the one for which the resistance scale is calibrated, resistance may be read directly in megohms. If some other voltage is selected, the current is read from the right-hand meter, the voltage from the left-hand meter, and resistance calculated from Ohm's law. Resistance may be read after 1 and 10 minutes and the ratio of these values calculated to obtain polarization index. Of course, the leakage current can be read at any selected voltage level, if this type of measurement is desired.

REFERENCES

1. Insulation Resistance of Armature Windings, **R. W. Wieseman.** AIEE *Transactions*, vol. 53, 1934, pp. 1010–21.

2. Field Testing of Generator Insulation, **Edison Electric Institute Subject Committee on Generator Insulation Testing.** AIEE *Transactions*, vol. 60, December 1941, pp. 1003–11.

3. Progress Report of D-C Testing of Generators in the Field, **E. R. Davis, M. E. Leftwich.** *Electrical Engineering*, vol. 61, January 1942, pp. 14–18.

4. Maintenance Over-Potential Tests for Armature Windings in Service, **R. W. Wieseman.** *General Electric Review*, Schenectady, N. Y., August 1950.

5. Testing Electrical Insulation of Rotating Machinery with High-Voltage Direct Current, **G. Leslie Hill.** AIEE *Transactions*, vol. 72, April 1953, pp. 159–74.

6. Absorption Studies on High-Voltage Machines, **W. Schneider.** *Electrical Engineering*, vol. 70, July 1951, p. 572.

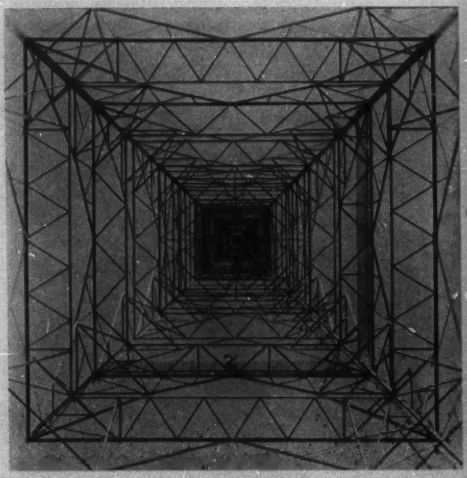
7. Insulation Field Test Results, **W. F. Dunkle.** *Ibid.*, p. 579.

8. Insulator Testing with High Voltage D-C, **G. Leslie Hill.** *Electric Light and Power*, Chicago, Ill., vol. 25, no. 47, November 1947, p. 2.

9. Recommended Practice for Testing Insulation Resistance of Rotating Machinery. AIEE Standard 43, April 1950.

10. Insulation-Resistance Meter, **R. N. Bushman.** *General Electric Review*, Schenectady, N. Y., vol. 46, no. 7, July 1947, p. 403.

Television Tower



This unusual picture was taken from the base of the 500-foot WENS television tower, built by Blaw-Knox Company, Pittsburgh, Pa. The tower is 49 feet square at the base, 3 feet square at the top, and contains 74 tons of structural steel.

Effect of Shock and Vibration on Relays

AIEE COMMITTEE REPORT

TWENTY-EIGHT electrical operating companies, surveyed by a questionnaire,* reported on 126 cases of faulty relay operations caused by shock or vibration within the past 10 years. Analysis of the replies indicates that approximately 53 per cent of the cases were caused by shock and 47 per cent of the cases caused by vibration. The vibration was caused by rotating machines or by transients such as passing trains or trucks. A majority of difficulties caused by shock occurred where relays were mounted on hinged panels.

Measurements taken on steel switchboard panels in power plants showed that amplitudes of vibration varying from 0.2 to 8 mils and frequencies between 30 and 190 cycles were encountered. The laboratory tests centered on determining the effect of shock on relays. Shock was applied either by hammer of varying weight or by moving the hinged panel on which the relays were mounted to a given angle by various weights suspended from the panel.

Only general statements can be made in summarizing the results because many factors influence the tests. It appears that the shock necessary to close the contact of the relay cannot be defined by acceleration alone, but rather by the product of acceleration and duration. The construction of the relay has an important bearing on the shock resistance. The clapper-type relays are generally more sensitive to shock in horizontal direction, while the plunger-type relays are relatively immune to shock caused by horizontal blows. The shock sensitivity of the relay with potential restraint or polarizing coil is increased if the restraint coil is de-energized.

Factors that reduce the faulty operation of relays are: (1) increased contact gap spacing; (2) increased armature torque; and (3) modification of backstop construction. Investigation of relay mountings on hinged panels showed that harmful shock caused by slamming can be controlled by mechanically limiting the panel-closing speed through door checks.

Changing the natural frequency of the relay moving element or armature has considerable effect on the shock necessary to cause faulty operation. Addition of mass lowers the natural frequency and an increase of the spring torque raises it. Relays with lower natural frequency are more likely to respond to shock-produced vibrations, which are predominantly in the range of 100 cycles per second.

In designing switchboard panels and metal-clad switchgear the following are a few of the provisions which might reduce the possibility of accidental relay operation due to shock or vibration: (1) use slate or composition panels where heavy shock or vibration is expected; (2) steel panels should be braced by horizontal or vertical webs to add stiffness; (3) insert shock- and vibration-absorbing layers between panels and phase foundations, and similar provisions can be made for wall braces; (4) avoid mounting shock-sensitive relays on steel doors; (5) provide rubber mount between relay and panel; and (6) provide door checks to control speed of closing and opening of hinged panels.

It also appeared that certain changes in the relays would increase the shock resistance of the relay. Some of these suggested changes are: (1) improve backstop construction; (2) increase restraining spring; (3) increase air-gap spacing between disk and magnets; (4) increase contact gap spacing; and (5) design clapper-type relays so that armature hinge is in a position with reference to the mounting place to assure the greatest shock resistance.

It can be concluded that: (1) vibration and shock problems are real with the electrical industry, and each cause appears to be of equal importance; (2) relays on steel panels are more susceptible to vibration and shock than relays mounted on panels such as slate or composition; (3) almost all types of relays have been reported to operate by vibration or shock, however, some relays are more sensitive than others; (4) hinged armature (clapper-type) relays as generally used in the power industry are more susceptible to shock whereas plunger-type relays are less likely to operate when subjected to shock in horizontal direction; (5) two general methods help to mitigate the effect of vibration on relays, namely, improvement in relay design and changes in mounting; (6) shock to relays could be caused by straight-line motion at right angles to the panel, by motion parallel to the panel, by rotary couple applied to the panel, by rotary couples applied to the relay, and by rotary couples produced by the operation of the hinged panel section; (7) shock resulting from the foregoing causes may be violent enough to cause relay operations, and there are several methods available to mitigate but not completely eliminate the effect of shock, namely, improvement in relay design, in panel design, relay mounting, and modification of electric circuits; (8) the location of door hinges (left or right) would have some effect of the shock sensitivity of certain types of relays depending on the position of the contact arm; (9) hinged armature relays can be redesigned with counterbalanced armature or with twin contacts, and pivot centrally located between contacts which may eliminate the effect of shock on relays; and (10) electric circuits may be modified so that the tripping circuit requires the closing of two independent contacts and by arranging these contacts to be in different planes.

Digest of paper 55-97, "Effect of Shock and Vibration on Relays," recommended by the AIEE Committee on Relays and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

This paper was prepared by the AIEE Project Committee on Effect of Shock and Vibration on Relays of the AIEE Committee on Relays.

*The AIEE Project Committee undertook a study of protective relay performance during shock and vibration as found under normal service conditions. The study consisted of the survey of the problem, laboratory and field tests, preparation of conclusions based on the survey, and the tests and presentation of several methods for mitigation.

Audio Amplifier Distortion Analysis and Measurement

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Some of the fundamental techniques for recognizing, measuring, and reducing unwanted distortion in the electronic amplifiers of audio systems are discussed. Three chief sources of electronic distortion—tube nonlinearity, circuit reactances, and random interference—are dealt with in some detail

UNDISTORTED CONVEYANCE OF SOUNDS and tonal structures through the dimensions of time and space has long been an engineering goal. In recent years, that goal has been brought nearer by microgroove recording, magnetic tape, and frequency modulation developments. Each of these has been a step forward in the reduction of distortion and the improvement of realism in sound reproduction.

THE NATURE OF SOUND

SOUND IS A PHYSIOLOGICAL SENSATION produced in the auditory centers of the brain when waves of air pulsating at frequencies within the range of approximately 20 to 20,000 cycles per second (cps) vibrate against the ear drums.

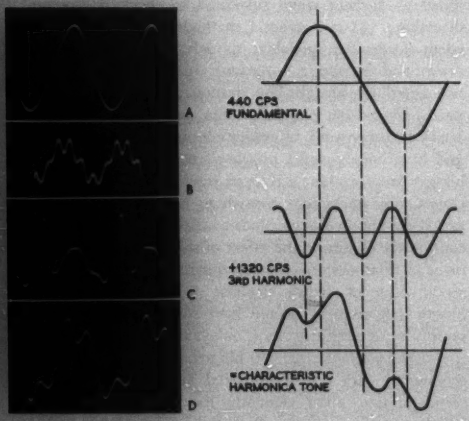

Fig. 1. Instrument waveforms: *A—Pure 440-cps sine wave; B—Clarinet; C—Trumpet; D—Harmonica; E (right)—Analysis of harmonica tone into its frequency components*

The only waveform consisting of just one single frequency is a pure sine wave such as that emitted from a tuning fork. See Fig. 1*A*. Most sounds are very complex waves consisting of a fundamental and many accompanying overtones or harmonics of the fundamental. It is the respective proportions of these overtones which provide timbre and character to sounds emitted from different sources. Thus, the different inherent harmonic vibratory characteristics of various instruments are clearly shown in Figs. 1*B*, 1*C*, and 1*D*. All instruments were playing middle A (440 cps).

SOURCES OF DISTORTION

A SOUND BECOMES DISTORTED whenever its original waveform is altered. In recording and playback alterations of the original sound waves may arise mechanically in microphones, recording and pickup equipment, and loudspeakers, and may arise electrically in poorly designed electronic or magnetic circuits. Electronic amplifying equipment is at the heart of all sound systems, and distortions arising therefrom will be discussed here.

Ideally, amplification is a process whereby vibratory power is increased without disturbing the time sequence and pattern of its oscillations. Since this is never perfectly realized, the amplifier has a certain percentage of distortion which, if excessive, deteriorates the audio quality and becomes annoying to the listener.

ELECTRONIC DISTORTIONS

THE THREE PRINCIPAL SOURCES of electronic distortion are tube nonlinearity, circuit reactances, and random interference. *Tube nonlinearity* can be subdivided into (1) harmonic and (2) intermodulation distortion; *circuit reactance*, into (3) frequency, (4) phase, and (5) transient distortions; and *random interference*, into (6) noise and hum. These six undesirable manifestations will be discussed in that order.

1. Harmonic distortion arises when a sinusoidal (single-frequency) input voltage comes out of the amplifier as a nonsinusoidal wave containing new and added frequency components. This results from nonlinear tube dynamic characteristics.

2. Intermodulation results from interactions between two or more input frequencies which give rise to sum and

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difference components or "beats" in the output. Like harmonic distortion, it is caused by nonlinear tube characteristics and always accompanies the latter when more than one input frequency is involved.

3. Frequency distortion arises when the amplifier gain is not equal for all frequencies. It is caused by circuit or tube reactances which change with frequency.

4. Phase distortion results when the relative phase differences between the various frequencies are not the same in the output as in the input. The same tube and circuit reactances which give rise to frequency distortion will cause phase shifts.

5. Transient distortion occurs when the amplifier is unable to handle the sudden stops and starts of percussion instruments and the like. Reactances are also the cause of this type of distortion.

6. Noise and hum result from a variety of causes such as thermal agitation of electrons in small-signal high-gain tubes, induced stray voltages, and poor power-supply filtering.

Each of these types of distortion will first be analyzed mathematically. Measurement techniques and effects upon reproduced sounds will then be considered.

1. *Harmonic Distortion.* If the dynamic transfer characteristic of a tube is a straight line, Fig. 2 left, it may be represented by a simple equation,

$$i_p = K_1 e_g \tag{1}$$

and the input and output waveshapes will be identical.

If, on the other hand, operation takes place over a curved portion, Fig. 2 right, the curve might be approximated by equation

$$i_p = K_1 e_g + K_2 e_g^2 \tag{2}$$

(. . . and higher terms $K_2 e_g^2$ etc. depending upon the curvature).

Now, if the input is a sine wave

$$e_g = E_m \sin wt \tag{3}$$

Substitution of this value in equation 2 yields

$$i_p = K_1 e_m \sin wt + K_2 E_m^2 \sin^2 wt \tag{4}$$

Then, total instantaneous plate current

$$i_b = I_b + i_p = I_b + K_1 E_m \sin wt + K_2 E_m^2 (1 - \cos 2wt)/2 \tag{5}$$

$$= I_b + (K_2 E_m^2)/2 + K_1 E_m \sin wt - (K_2 E_m^2/2) \cos 2wt \tag{6}$$

$$\text{or } i_b = I_b + B_0 + B_1 \sin wt - B_2 \cos 2wt \tag{7}$$

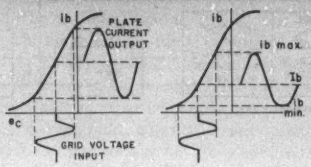
where the B's are the inclusive constants and represent harmonic amplitudes. These can be determined by substituting values of 0, $\pi/2$, and π for wt in equation 7. Solving

$$B_1 = (i_{b\,max} - i_{b\,min})/2 \tag{8}$$

$$B_2 = (i_{b\,max} + i_{b\,min} - 2Ib)/4 \tag{9}$$

$$\text{and } B_0 = B_2 \tag{10}$$

Values of I_b, $i_{b\,max}$, and $i_{b\,min}$ corresponding to a chosen value of e_g may be obtained from the dynamic transfer characteristic or an oscilloscope tracing of the plate current shown in Fig. 2 (or plotted from the plate diagram as shown in Fig. 3) and the harmonic amplitudes B_1 and B_2 obtained therefrom.



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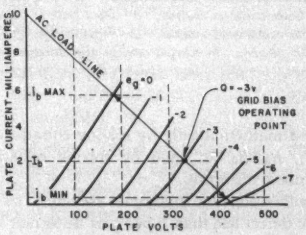

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Fig. 2. Tube dynamic transfer characteristics: *A—Linear operation using proper bias; B—Nonlinear harmonic distortion of output caused by excessive bias.* **Fig. 3. Tube plate characteristic curves** *showing effect of large signal and excessive bias as in Fig. 2. Harmonic distortion appears as unequal distortions along the a-c load line*

The distortion of a particular harmonic is usually published as a percentage compared to the fundamental, such as $B_2/B_1 \times 100$ per cent. Total harmonic distortion is the ratio of the effective values of all the harmonics to that of the fundamental, or

$$\text{H.D.} = \sqrt{B_2^2 + B_3^2 + B_4^2}/B_1 \ldots \times 100 \text{ per cent} \tag{11}$$

assuming higher order distortion products are present.

Nonlinear distortion is most apt to occur in the power output stages where the grid voltage swing is considerable, and the tubes are often driven into nonlinear regions. By designing the output in a balanced push-pull arrangement, even-harmonic distortion generated in one of the tubes is canceled by its out-of-phase counterpart in the other. This eliminates one of the largest distortion components in most output stages.

As for measurement, the ear is perhaps the most sensitive and critical of all means of measuring distortion. In the final analysis, it is the listener who subjectively determines whether a musical amplifier system is tolerable.

For more comprehensive measurements, a good-quality oscilloscope, sine- and square-wave generator, and a-c vacuum-tube voltmeter are required.

Harmonic distortion may be detected by noting the output waveform quality on an oscilloscope when a sine wave is being fed into the amplifier. The approximate relative amplitudes of $i_{b\,min}$, $i_{b\,max}$, and I_0 are determined from the trace, and harmonic distortion percentages are

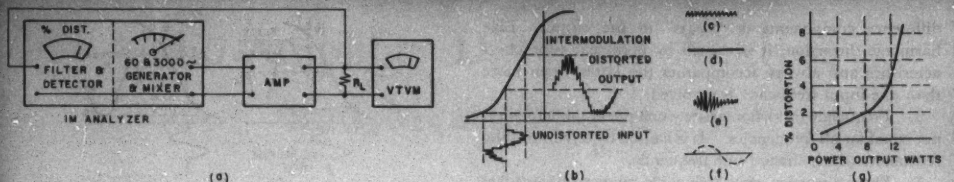


Fig. 4. Intermodulation measurement: *A—Test setup showing load resistor R_L inserted (to provide constant rated load on amplifier) and complete intermodulation-measurement analyzer; B—Input wave of 60 and 3,000 cycles mixed 4:1; C—Input waveform after filtering the 60-cycle component in the intermodulation-measurement analyzer; D—Input envelope after detection and removal of the 3,000-cycle component (zero signal is fed to meter); E—Output waveform after filtering; F—Output envelope after detection and removal of 3,000-cycle component, showing signal which actuates meter directly to percentage distortion figure; G—Plot of intermodulation distortion vs. power output (where $P_o = E_o^2/R_L$)*

determined mathematically by solving equations 8, 9, and 10 for B_1, B_2, B_0 etc., and by solving equation 11 for total harmonic distortion.

Harmonic distortion analyzers are often used as it is difficult to detect less than 5-per-cent distortion visually on an oscilloscope. These analyzers filter out the fundamental frequency and pass only the residual harmonics for measurement. Theoretical distortion may be determined from the plate characteristic curves as in Fig. 3. The d-c operating point Q is located on the load line and grid drive (3 volts in the example) applied. The plate currents corresponding to minimum and maximum grid excursions are determined, as well as the d-c static current at no signal, and the same equations applied as in the foregoing. If the ratio of positive to negative swing is 1/1, there is no distortion; and if it is 9/11, the distortion is 5 per cent, which was the prewar standard of high quality. Today, the standard for high-quality amplifiers is approaching 0.1 per cent of total harmonic distortion at full rated output.

2. *Intermodulation Distortion.* Since intermodulation arises from the same nonlinear tube operation as does harmonic distortion, the same mathematical analysis may be used. Now, however, the interaction between two input frequencies is being dealt with so

$$e_g = E_1 \sin w_1 t + E_2 \sin w_2 t \qquad (12)$$

Then $$i_b = I_b + K_1(E_1 \sin w_1 t + E_2 \sin w_2 t) + K_2(E_1 \sin w_1 t + E_2 \sin w_2 t)^2 \qquad (13)$$

Expanding $$i_b = I_b + (K_2/2)(E_1^2 + E_2^2) + K_1 E_1 \sin w_1 t + K_1 E_2 \sin w_2 t - (K_2 E_1^2/2)(\cos 2w_1 t) - (K_2 E_2^2/2)(\cos 2w_2 t) + K_2 E_1 E_2 \cos(w_1 - w_2)t - K_2 E_1 E_2 \cos(w_1 + w_2)t \qquad (14)$$

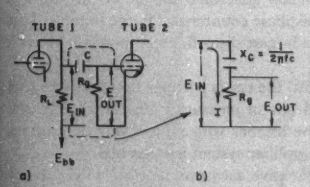
So $$i_b = I_b + B_0 + B_1 \sin w_1 t + B_2 \sin w_2 t - B_3 \cos 2w_1 t - B_4 \cos 2w_2 t + B_5 \cos(w_1 - w_2)t - B_6 \cos(w_1 + w_2)t \qquad (15)$$

Not only are the previous second-harmonic distortion products present, but the new sum $(w_1 + w_2)$ and difference $(w_1 - w_2)$ "beat" frequencies are also in the output. Although these frequencies may have small amplitude, they are quite noticeable as a dissonant background noise or chatter which bears no definite musical or harmonic relationship to the original tones and appears to vary with the loudness of the signal. This is much more objectionable than harmonic products which are harmonically related to the input and not necessarily displeasing even though they do alter the original tonal quality to some degree.

Intermodulation tests are made by injecting two frequencies into the amplifier input simultaneously, usually one in the low end of the spectrum and the other in the high end, and detecting and measuring the resulting output modulation envelope. Commonly used frequencies are 60 and 3,000 cycles mixed in a 4 to 1 ratio. See Fig. 4.

The amplifier output is applied to a load resistor R_L of rated value and size rather than to a normal loudspeaker load, in order to eliminate varying reflected speaker impedances and other external factors.

If nonlinearity is present, the high frequency will be un-



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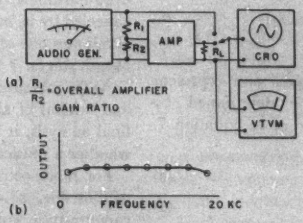

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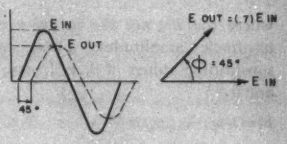

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Fig. 5. Interstage coupling reactances: *A—Actual circuit; B—Equivalent circuit, showing reactive voltage-divider action.* **Fig. 6. Frequency-response measurement.** *A—Typical test arrangement showing input voltage-divider R_1R_2 and resistive output load R_L; B—Frequency-response curve of typical amplifier.* **Fig. 7. Effects of phase shift on signal:** *A—Phase shift and amplitude distortions caused by interstage reactances of Fig. 5; B—Vector diagram of same showing relationship of input and output voltages*

evenly amplified on the positive and the negative extremes of the large low-frequency swing. If the low-frequency component is then filtered out in the analyzer input, the high frequency will appear as an AM signal with a modulating frequency of 60 or 120 cycles, depending on whether the flattening occurs on one or both peaks of the low-frequency swing. Fig. 4 shows flattening only on the negative peak.

The modulating signal is next detected in the analyzer, and the resultant rms voltage actuates a meter which indicates the percentage distortion figure. Obviously, there would be zero intermodulation distortion if there were no modulation of the envelope and consequently, no rms voltage to the meter, as in Fig. 4*E*.

Although the testing equipment is expensive, this is probably one of the most significant and revealing amplifier tests, since intermodulation background "hash" is directly related to listener fatigue and irritability. Results usually indicate two to four times as much intermodulation as harmonic distortion, and consequently manufacturers are often reluctant to publish intermodulation figures on their equipment. The better amplifiers today will generate less than 1.0 per cent intermodulation at rated output.

3. *Frequency Distortion.* Frequency distortion arises because circuit reactances, such as coupling capacitors and tube interelectrode capacitances, vary with frequency.

As an example, let the signal voltage from tube *1* be E_{in}. See Fig. 5*A*. This signal voltage is applied to tube *2* across R_g after passing through coupling capacitor *C*, inserted to keep direct current off the second grid. *C* and R_g, however, form a voltage divider as shown in Fig. 5*B*, whose alternating current *I* is

$$E_{in}/(-jX_c+R_g) \tag{16}$$

At low frequencies, $-jX_c$ becomes quite large and *I* therefore decreases, causing a corresponding decrease in $IR_g = E_{out}$. Consequently the lower frequencies are not amplified as much as the highs. If R_g and *C* are both large, this defect does not become noticeable until the frequency is very low. *C* is limited, however, by leakage, physical size, and cost; R_g by the grid ion bombardment of tube *2*.

Frequency discrimination of this type is used advantageously in tone-control circuits where circuit reactances are used purposely to accentuate certain frequency ranges and subdue others. In the design of amplifiers, it is best to furnish a wide-range "flat" response and then provide the listener with flexible tone controls to compensate for varying mechanical and acoustic conditions to his own personal satisfaction.

In one sense, of course, this amounts to "controlled distortion," since it does not introduce new or strident sounds not present in the original performance, but rather merely blends those original sounds in different proportions, it can be used to increase listener enjoyment.

Frequency-response measurements may be made by injecting one frequency at a time into the amplifier and recording each respective input and output amplitude as read on an a-c meter. Tone controls, of course, should be by-passed or set in the "flat" position. The resulting gain ratio is plotted point by point to give a curve which would ideally be a perfectly straight line, but which in reality droops at the frequency-range extremes. A voltage divider equal to the approximate amplifier gain ratio is used at the input, as shown in Fig. 6, so that the meter need not be continually shifted in range when switched to the output.

The input is read and adjusted before each output reading in order to compensate for the possibility that the audio generator output and meter response may not be constant. Also, the output leads may be connected across the vertical input of an oscilloscope for visual monitoring purposes and to assure that readings are taken below distortion levels.

Response variation no greater than ± 0.1 db over the entire audio range from 20 to 20,000 cycles is achieved in many current amplifiers.

4. *Phase Distortion.* Phase distortion has the same origin as frequency distortion and may be illustrated by solving the preceding problem with specific values.

Assume that at frequency f_1, X_c is negligible compared to R_g.

$$\text{Then } I = E_{in}/R_g \tag{17}$$

$$\text{and } E_{out} = E_{in}R_g/R_g = E_{in}\underline{/0^\circ} \tag{18}$$

At some lower frequency, f_2, however, X_c will equal R_g in ohms.

$$\text{Then } I_2 = E_{2\,in}/(R_g - jX_c) = E_{2\,in}/(\sqrt{2}R_g\,\underline{/-45^\circ}) \tag{19}$$

$$\text{So } E_{2\,out} = (E_{2\,in}\,\underline{/45^\circ}R_g)/1.414R_g = 0.707E_{2\,in}\,\underline{/45^\circ} \tag{20}$$

Not only will the amplitude of f_2 voltage be reduced to 70 per cent of its true relative value, but the wave will be shifted ahead 45° in phase relative to its proper position. See Fig. 7.

At the higher frequencies, distributed wiring and tube interelectrode capacities begin to be a factor, acting as shunt capacities to ground and shifting the phases of these frequencies.

Since it is apparently impossible to do away with these various reactances, some phase distortion must always be

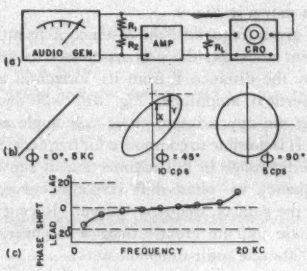

Fig. 8. Phase-shift measurement: *A—Typical test arrangement showing audio generator signal applied to horizontal sweep of oscilloscope; B—Oscilloscope patterns for phase shifts at various frequencies; C—Phase-shift curve of typical amplifier*

9

10A

10C

10B

11

12

Fig. 9. Phase-pattern distortion. Flattening of both peaks caused by amplifier being overdriven into nonlinear regions on both "knees" of its over-all linearity curve. Fig. 10. Square-wave development: *A—Fundamental sine wave; B—Addition of a 3d; harmonic of 1/3 fundamental amplitude; C—Further squaring by addition of next odd harmonic (the 5th).* **Fig. 11. Square wave applied to amplifier input. Fig. 12. Distorted output square wave. Concave pattern results from excessive attenuation of fundamental frequency**

present in a wide-range amplifier in some portion of its frequency range. Fortunately, however, the human ear seems to tolerate phase distortion without feeling any noticeably unpleasant effects. It is important, none the less, that the phase shift not approach 180° in any amplifier section around which feedback is applied, since this would actually apply positive or regenerative feedback at such frequencies and cause oscillations and instability.

Phase shift may be measured by connecting the amplifier output to the vertical oscilloscope input as usual, and the signal source to the horizontal oscilloscope input as well as to the amplifier input through a voltage divider as shown in Fig. 8. The signal source is therefore used as the sweep frequency base in place of the internal sawtooth sweep of the oscilloscope.

Since the vertical and sweep frequencies are the same, the pattern should be a stable one, and it will appear as a diagonal line, ellipse, or circle, depending upon the phase relationship of the two voltages, assuming that no nonlinear distortion is being introduced within the amplifier, in which case there may be kinking or flattening of the pattern as shown in Fig. 9.

At any given frequency, the distance X from the center to the point at which the pattern crosses its vertical axis divided by the distance Y from its horizontal axis to the greatest vertical amplitude, Fig. 8*B*, will equal sin ϕ, where ϕ is the approximate phase-shift angle at that frequency. It is possible to compute ϕ for frequencies throughout the audio range in this manner and it can be plotted as a frequency vs. phase-shift response curve, Fig. 8*C*, similar to the gain vs. frequency curve. Recent amplifiers have a phase shift no greater than ±15° over the entire 20- to 20,000-cycle audio range.

5. *Transient Distortion.* When a signal of f cycles is suddenly applied, signals of many times f are momentarily generated by the initial steep wavefront. If these extremely high frequencies are attenuated by the amplifier, the reproduced sound will lack the sharpness or incisiveness—the illusive "presence" effect—of the original.

For this reason, an amplifier with a frequency limit of 5,000 cycles or so is incapable of recreating the full impact of a live musical performance even though the musical instruments themselves generate fundamental tones no higher than about 4,600 cycles (the highest note on a piccolo). This explains the trend toward amplifier bandpasses to 20,000 cycles and more.

A particularly sharp transient is generated by the leading edge of a square wave. A Fourier analysis shows that a square wave is actually composed of a fundamental and an infinite number of odd harmonics whose relationship is given by the equation

$$e = E_{s.w.} 4/\pi \, (\cos wt + {}^1/_3 \cos 3wt + {}^1/_5 \cos 5wt + {}^1/_7 \cos 7wt \ldots) \quad (21)$$

where $E_{s.w.}$ = peak value of the square wave.

Thus, it can be seen that many frequencies have combined in proper phase to give the sharply rising edges of the square wave. If circuit and tube reactances within the amplifier limit its ability to amplify all these frequencies equally well, the resulting output wave will no longer be sharply squared. This illustrates also the close correlation between transient response and a wide flat bandpass.

Square-wave analysis gives the best indication of transient response. The oscillographs of Fig. 10 show the early development of a square wave from a fundamental sine wave of unity amplitude. The effect of the addition of a third harmonic of 1/3 amplitude and a fifth harmonic of 1/5 amplitude is clearly shown. Addition of the higher harmonics shown previously by the Fourier analysis squares the wave and straightens the peaks until finally, the pure clean square wave of Fig. 11 is formed.

Square waves generally are obtained, however, by greatly amplifying a sine wave and then clipping off most of both peaks, or by means of multivibrator circuits. If the corners of the resultant wave are sharply squared, it may be concluded that at least the first 11 harmonics are present in proper strength.

Thus, if the leading edge of a 500-cycle square wave input emerges from an amplifier sharply squared without

any rounding, the amplifier may be considered flat up to the 11th harmonic, or 5,500 cps. Similarly, sharp response to a square wave with a fundamental repetition rate of 2,000 cycles indicates an amplifier bandpass beyond 20,000 cycles.

If, however, the leading edge is rounded, this is an indication that the higher frequencies are attenuated, resulting in poor transient response. Also, if the top line of the output wave tilts upward, a lagging low-frequency phase shift is indicated, whereas if the tilt is downward, the lower frequencies present in the square wave have been shifted forward in phase.

The extreme low frequencies may be checked by feeding in a square wave of only 20 to 50 cps. A pronounced concaveness of the originally flat top and bottom peaks, as shown in Fig. 12, indicates attenuation of the fundamental base frequency.

Tiny parasitic oscillations or ringings caused by distributed wiring reactances, etc., may also be detected visually by square wave testing, appearing as dampened ripples on the peaks. Poorly designed coupling networks with low resistance-capacitance time constants to the higher frequencies will result in differentiation or "spiking" of high-repetition-rate square waves.

It is obvious, then, that square wave testing may be used to determine the approximate frequency and phase limitations of an amplifier as well as its transient response, without resorting to tedious point-by-point frequency readings. It also presents actual dynamic operating characteristics much better than the static tests do.

6. *Noise and Hum.* Amplifier noise originates primarily in low-level stages, and results from such things as leaky capacitors, "noisy" carbon resistors and potentiometers, microphonic tubes, etc., as well as from "thermal" noise.

Thermal noise is caused by the random motions of free electrons in conductors such as tubes and resistors. These random currents cause a potential difference across the terminals of the conductor whose (rms)^2 amplitude is proportional to the temperature, resistance, and bandpass range of the conductor. At 63 F, the thermal agitation across a resistor may be expressed as

$$E^2 = 1.6 \times 10^{-20} \times R(f_1 - f_2) \qquad (22)$$

where $(f_1 - f_2)$ = the bandpass of the conductor. Such noise is manifested as a background hissing or rushing sound which appears as a general blur on the oscilloscope since its frequency components are highly random. It may be reduced by using noninductive wire-wound resistors and special low-noise nonmicrophonic tubes in these early stages.

Hum is caused by insufficient power-line filtering and by electromagnetic and electrostatic pickup. Ground loops induce hum by inductive coupling according to Faraday's law

$$e = N d\phi/dt \qquad (23)$$

where N represents the "loop" or turn affected by the changing flux $d\phi/dt$.

The origin of hum may be largely determined from its oscilloscope pattern. Straight capacitive pickup from high-impedance grid circuits and heater-cathode leakage shows as a slightly rough 60-cycle wave, whereas inductive hum picked up by transformers is rich in harmonics (yet free from sharp peaks and spikes). Nearby fluorescent light interference is characterized by spikes and hash superimposed over the 60-cycle wave. Power supply ripple due to insufficient filtering is a very smooth 120-cycle note.

Careful amplifier construction and wiring techniques will eliminate most hum problems. Orientation of transformers for minimum inductive pickup, shielding and shock-mounting of extremely low-level tubes and circuits, adequate power supply and a-c input line filtering, isolation of grid circuits from a-c wiring, twisting of filament wiring and center-tapping of the filament winding to ground, and the use of a single bus-wire ground system attached to the chassis at only one point are some of the precautions which are taken to give some current amplifiers the very low hum and noise levels of 90 db below rated output.

CONCLUSIONS

A LARGE SYMPHONY ORCHESTRA generates its fabric of sound from 100 or more sources of vibrating strings, reeds, diaphragms, and such, over an area of perhaps 500 square feet. This extremely complex wave pattern is picked from the air, fed to a recording system, and finally permanently inscribed.

A home sound system is then called upon to recreate the impact and beauty of the original performance by amplifying the inscribed signal thousands of times and applying the resultant electric power through a small voice coil and about a square-foot area.

Considering the innumerable sources of distortion possible in the journey of the sound patterns from concert hall to home, it is a tribute to the engineering profession that this process may be accomplished today with such true and realistic fidelity. Furthermore, new developments such as stereophonic reproduction, with its recreation of original spatial as well as structural patterns and relationships, have been introduced and hold promise for even greater realism in future sound reproduction.

REFERENCES

1. Circuit Theory of Electron Devices (book), **E. Milton Boone.** John Wiley and Sons Inc., New York, N. Y., 1953.

2. Heathkit Technical Application Bulletins. Heath Company, Benton Harbor, Mich., 1953.

3. High Fidelity—Design, Construction, Measurements (book), Gernsback Publications, Inc., New York, N. Y., 1953.

4. *High Fidelity Magazine*, AudioCom Inc., Great Barrington, Mass., 1951–54.

5. High Fidelity Techniques (book), **James R. Langham.** Radcraft Publications Inc., New York, N. Y., 1950.

6. The Recording and Reproduction of Sound (book), **Oliver Read.** Howard W. Sams and Company, Inc., Indianapolis, Ind., 1952.

7. Electron Fundamentals and Applications (book), **John D. Ryder.** Prentice Hall Inc., New York, N. Y., 1950.

8. Alternating Current Circuits (book), **K. Y. Tang.** International Textbook Company, Scranton, Pa., 1951.

9. Radio Engineers Handbook (book), **Frederick E. Terman.** McGraw-Hill Book Company, New York, N. Y., 1943.

10. Handbook of Sound Reproduction, **Edgar M. Villchur.** Chap. 15, pt. II, *Audio Engineering Magazine*, Mineola, N. Y.

11. Experiments in Electronics (book), **Platt Wicks.** Edwards Brothers, Inc., Ann Arbor, Mich., 1949.

Testing of Valve-Type Lightning Arresters

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A LIGHTNING ARRESTER must function as an insulator under normal system line-to-ground voltage conditions, discharge without damage the complete range of transient disturbances expected in normal service, and interrupt the power frequency follow current resulting from these transient disturbances.

Tests suitable for lightning arrester standards, that is, capable of reasonable duplication among different laboratories, however, bear rather limited relation to actual service duty. Such tests include:

1. Duty cycle testing with full rated voltage during follow current flow.
2. Duty cycle testing in high-reactance circuit to explore gap-interrupting ability.
3. Duty cycle testing with impulse and power voltage of opposite polarity—a likely service condition, and one that is more severe.
4. Duty cycle testing at the rate of several operations per second to obtain the local high-temperature regions in valve elements occurring under such conditions.
5. Impulse discharge during follow current flow—a possible service condition during multiple strokes.
6. Switching surge tests—that is, long duration tests where impulse generator charge voltage rather than discharge current is the criterion for judging performance.
7. Evaluation of Y-connected power transformers on switching surge duty.

Tests were performed on standard production units of arresters designed for station use. The type *GP* is designed for general purpose station use in voltage ratings of 3 to 121 kv. The type *MP* offers better protective characteristics and greater durability than the type *GP*. Voltage ratings are 3 through 276 kv.

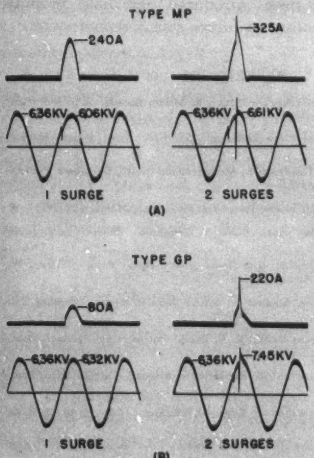

Fig. 1. (A) Oscillograms showing effect of 100-kiloampere 5 × 9-microsecond surge during follow current flow on a type MP lighting arrester. Circuit fault current was 1,000 amperes rms. (B) Oscillograms of same test on type GP arrester

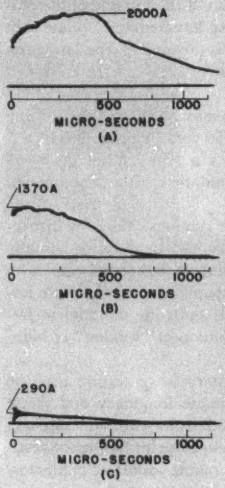

Fig. 2. Oscillograms of tests simulating the discharge of 18 miles of 138-kv cable. (A) Discharge through 12-kv type MP lightning arrester. Simulates discharge of the cable through a 121-kv type MP lightning arrester. (B) Discharge through 12-kv type MP lightning arrester with duty cycle test transformer in parallel. Simulates discharges of the cable through a 121-kv type MP lightning arrester protecting a large grounded Y - connected power transformer. (C) Discharge through 12-kv type GP lightning arrester with duty cycle test transformer in parallel. Simulates discharge of the cable through a 121-kv type GP lightning arrester protecting a large grounded Y-connected power transformer

Fig. 1 illustrates an effect encountered when valve-type arresters are called upon to discharge 100 kiloamperes while already conducting follow current. The severity of this duty, in addition to that of the high-current impulse itself, is illustrated by the high-current long-duration peaks shown on the right-hand oscillograms.

Fig. 2 illustrates the effect of lightning arrester characteristics and the presence of grounded power transformers upon switching surge currents discharged by lightning arresters. These oscillograms were obtained during tests simulating 18 miles of 138-kv 1,000-thousand-circular-mil cable charged to 2.5 times normal line-to-ground voltage and discharging through 121-kv lightning arresters. The oscillogram of Fig. 2*A* represents the discharge through a 121-kv type *MP* arrester. The oscillogram of Fig. 2*B* represents the discharge through the same arrester with a 30,000-kva 10 per-cent impedance 138-kv solidly grounded transformer connected across the cable and lightning arrester. The oscillogram of Fig. 2*C* was obtained under conditions identical to those of Fig. 2*B* except a 121-kv type *GP* lightning arrester was represented rather than the type *MP*.

Digest of paper 55-136, "Transient Durability Testing of Valve-Type Lightning Arresters," recommended by the AIEE Committee on Protective Devices and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York N. Y., January 31-February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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Effects of Pole and Zero Locations on Response

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THIS digest extends a method devised by Mulligan[1] whereby the maxima and minima of the step response of fixed linear systems are determined without having to evaluate the entire response by using distances and angles between pole and zero locations of the system function.

Let the Laplace transform of the unit step response for a system which is initially at rest be $F(s)$, then

$$F(s)=\frac{\prod_{i=1}^{m}(s+\mu i)\prod_{i=1}^{g}[(s+\xi i)^2+\gamma i^2]}{s\prod_{i=1}^{q}(s+\rho i)\prod_{i=1}^{n}[(s+\alpha i)^2+\beta i^2]}=\frac{Z(s)}{s}$$

It is assumed that $2n+q>2g+m$, and that the system function $Z(s)$ has no poles in the right half s plane or on the imaginary axis, no zeros at the origin, and no multiple poles. The poles and zeros are numbered consecutively according to the magnitude of their real parts starting with the one with the lowest real part. See Fig. 1.

Labeling the points of time where the step response crosses its final value by T_1, T_2, T_3, —, T_t, —, the values of these points are given by $\beta_1 T_t=c\pi-\lambda_1-\psi_1+x_t$, where

$$\lambda_1=\sum_{i=1}^{g}\theta_{i1}-\sum_{i=2}^{n}\psi_{i1}+\sum_{i=1}^{m}\delta_{i1}-\sum_{i=1}^{q}\phi_{i1}$$

and β_{1k}, ψ_{1k}, θ_{i1k}, ψ_{i1k}, δ_{i1}, and ϕ_{i1} are defined in Fig. 1. The integer c equals $d+1$ where d is the largest integer for which $d\pi-\lambda_1-\psi_1$ is negative. x_t is a correction term whose value can be obtained by a trial and error method. However, when there is large separation between the poles in the s plane, especially horizontal separation between the first pair of poles and the others, with no complex poles too near the real axis other than the first pair and with no zeros too close to the first pair of poles, the x_t will in general be small as compared to $c\pi-\lambda_1-\psi_1$ and can be neglected.

The angles θ_{i1}, ψ_{i1}, δ_{i1}, and ϕ_{i1} can be obtained from Fig. 2. That is, the pole and zero locations are normalized by dividing each co-ordinate by β_1 and entering this position into the figure. The imaginary axis is taken to pass through the first pole pair $-\alpha_1\pm j\beta_1$. Complex pole or zero pairs to the right of the dominant pole pair produce a negative contribution to ψ_{ik} or θ_{ik}, and those to the left produce a positive contribution. Moreover, real elements on the left contribute one half the value indicated, while those to the right contribute π minus half the values indicated.

Thus, to determine approximately the points where the step response crosses the final value line, one need only calculate the angles θ_{i1}, ψ_{i1}, δ_{i1}, ϕ_{i1}, and ψ_1 which occur on the pole and zero location chart and then substitute these values into equation 2 setting $x_t=0$.

REFERENCES

1. The Effect of Pole and Zero Locations on the Transient Response of Linear Dynamic Systems, **J. H. Mulligan, Jr.** *Proceedings*, Institute of Radio Engineers, New York, N. Y., vol. 37, May 1949, pp. 516–29.

2. Investigation of the Transient Response of Linear Systems, **A. H. Zemanian.** *Doctoral Dissertation*, New York University, New York, N. Y., 1953, chap. 6.

Digest of paper 55-185, "Further Effects of the Pole and Zero Locations on the Step Response of Fixed Linear Systems," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Applications and Industry*, 1955.

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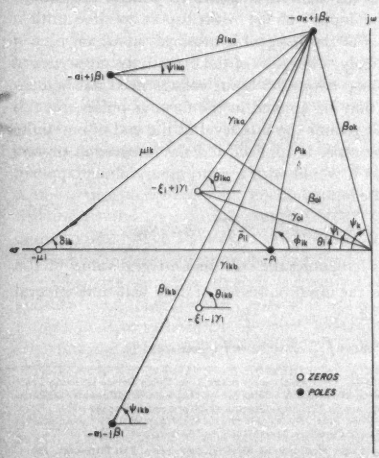

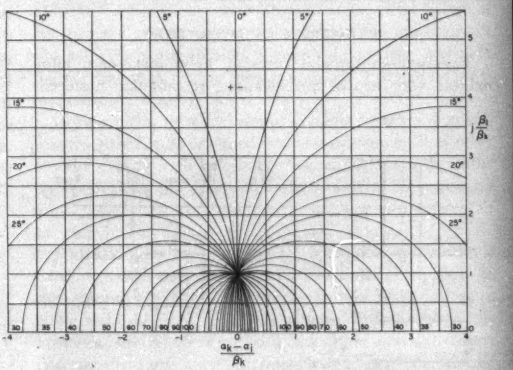

Fig. 1 (left). Notations employed for the pole and zero locations.
Fig. 2 (above). Constant ψ_{1k} and θ_{1k} curves

A Time-Delay Device Using Transistors

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Time-delay devices that perform pulse-shaping and pulse-counting functions now use junction transistors and rectangular hysteresis-loop magnetic cores for reliable operation over wide temperature ranges and voltage variations.

THE FIXED voltage-time integral value determined by the swing of the flux level of a rectangular-hysteresis-loop magnetic core from one saturation level to the other has been exploited in a variety of ways; e.g., magnetic amplifiers, saturating transformers, etc. Nevertheless, extensive utilization of the integrating capabilities of cores has been limited by the functions which associated circuit components are capable of performing. Employing junction transistors as circuit components, however, opens new possibilities of using this characteristic of saturable cores to perform a variety of useful functions.

This article describes circuitry employing junction transistors as nearly ideal controlled switches in conjunction with rectangular-hysteresis-loop magnetic cores to perform pulse-shaping and preset pulse-counting functions.

By deriving pulses from a fixed-frequency source, the circuitry may be designed to yield quite long time delays with extreme accuracy, because of the digital nature of operation employed. The circuitry and the manner in which transistors are used permits operation under conditions of relatively wide supply-voltage variations and ambient temperatures extending to at least 80 C without adversely affecting the timing accuracy.

PRINCIPLES OF OPERATION

TAPE-WOUND toroidal cores of 50-50 nickel-iron alloy exhibit very nearly the idealized rectangular hysteresis loop shown in Fig. 1*A*. Essential features of this magnetic characteristic are the sharp saturation at some definite core flux ϕ_s and the retention of the existing core flux level upon removal of all applied magnetomotive forces.

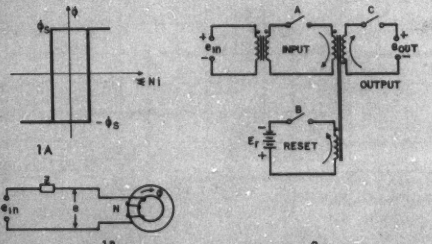

Fig. 1A. Idealized rectangular hysteresis loop. Fig. 1B. Simple saturable-core circuit. Fig. 2. Basic preset counter circuitry

Suppose that such a core is provided with a winding and a voltage is applied, as shown in Fig. 1*B*. The voltage $e = N(d\phi/dt)$ is the voltage "absorbed" by the core in changing its flux level in response to the applied voltage e_{in}. Changes in core flux level can therefore be related to the volt-time integral of the voltage e:

$$\Delta\phi = \frac{1}{N}\int_{\Delta t} e\,dt$$

From this it is seen that, if core flux is changed from negative to positive saturation, a volt-time area must be supplied to the core equal to

$$\int e\,dt = 2N\phi_s$$

If the voltage drop across the series impedance element Z of Fig. 1*B* (which includes winding resistance as well as any other series impedances) is negligible compared to e_{in} and e then

$$e_{in} = e$$

and

$$\int e_{in}\,dt = 2N\phi_s$$

Thus, if a low-resistance winding on the core is supplied with voltage from a low-impedance source, the core (assuming that it is driven from negative to positive saturation) integrates the input voltage with respect to time until a definite value of the integral is attained, at which time it saturates sharply. Because of the retentivity properties of rectangular-loop cores, the input voltage need not be continuous but may be applied in the form of pulses; in this case, the core retains the flux level at the end of one pulse until the next pulse is applied, and the integration process takes place as it would with a continuous voltage applied. Thus, for pulse input voltages

$$\int_{\Delta t_1} e\,dt + \int_{\Delta t_2} e\,dt + \int_{\Delta t_3} e\,dt + \ldots + \int_{\Delta t_n} e\,dt = 2N\phi_s$$

where $\int_{\Delta t_n} e\,dt$ denotes the volt-time integral value of the nth pulse. If the input pulses are of fixed volt-time integral value; i.e., if

$$\int_{\Delta t_1} e\,dt = \int_{\Delta t_2} e\,dt = \int_{\Delta t_3} e\,dt = \ldots = \int_{\Delta t_n} e\,dt,$$

Full text of paper 55-74, "A High-Accuracy Static Time-Delay Device Utilizing Transistors," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Published in AIEE *Communication and Electronics*, March 1955, pp. 54–8.

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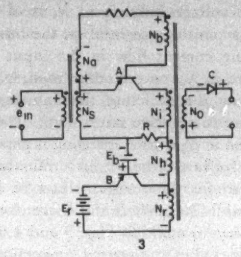

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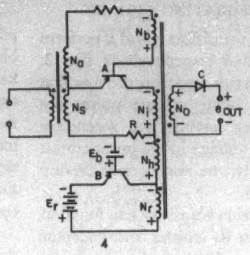

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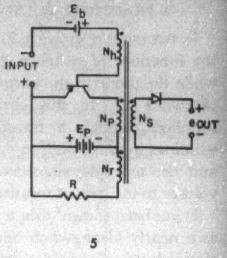

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Fig. 3. Preset counter circuit during an input pulse. Fig. 4. Preset counter circuit during resetting. Fig. 5. Pulse-shaper circuit

then

$$n\int_{\Delta t_n} e\,dt = 2N\phi_s$$

or

$$n = \frac{2N\phi_s}{\int_{\Delta t_n} e\,dt}$$

so that a definite number of input pulses are required to saturate the core. It is this voltage-integrating property of the rectangular-loop saturable core, particularly with pulse inputs, which forms the basis of operation of the device to be described.

If a core is initially placed in the negative saturation state and the saturation of the core in the positive direction is detected and an output signal immediately initiated, a variety of useful functions can be performed by virtue of the integrating property of the core. For instance, if the input voltage of Fig. 1*B* varies in a random manner with time, an output signal will be obtained when the time integral of the input voltage attains some fixed value, as determined by the saturation flux of the core and the number of turns of the input winding. On the other hand, if e_{in} consists of a series of unidirectional pulses of equal volt-time area; then, as pointed out, a fixed number of such pulses will be required to drive the core from negative to positive saturation, and an output signal will be obtained after application of a preset number of pulses. If such input pulses are supplied synchronously with a fixed-frequency source; e.g., an a-c power source, a given number of pulses will represent a fixed time interval, and an output signal will be delivered after a preset time interval.

Since, in general, it is desirable to reset the core immediately to negative saturation after it has been driven to positive saturation, a convenient means of obtaining an output signal is provided since the voltage induced in an output winding on the core during resetting serves ideally as an output pulse. Such a pulse has a fixed volt-time area determined by the core saturation flux and the number of turns of the output winding; thus, it is ideally suited to drive another core, operating in a similar manner, partially toward positive saturation. By such cascading the range of integration or counting can be greatly extended.

Although the principle of operation of a magnetic-core integrator as set forth is quite elementary and straightforward, the circuitry required to reduce the principle to practice is quite specialized in its required functions.

BASIC CIRCUITRY

BASICALLY three circuits are required. These are as follows:

1. An input circuit and winding providing a means of applying input voltage pulses to the core.
2. A reset circuit and winding providing a means for resetting the core to negative saturation upon saturation in the positive direction.
3. An output circuit and winding providing a means of applying the induced voltage during resetting to a load or succeeding stage.

These circuits are shown schematically in Fig. 2, each incorporating a switch which it is assumed may be opened and closed at appropriate times.

During an input voltage pulse it is desired that the entire input voltage be translated into core flux change. This dictates that the input circuit possesses low series impedance other than the inductive impedance of the core and that current flow in the input circuit be kept to a minimum. The latter condition implies that there be no loading on the core because of other circuits linking it. Therefore, during input pulsing, it is required that switch *A* be closed and switches *B* and *C* be open.

During resetting it is desired that the resetting battery voltage be applied to the resetting winding, and that the voltage induced in the output winding be transmitted to the output terminals. Since the input circuit has been specified to be of very low impedance, it is necessary that switch *A* be opened during resetting in order that the input circuit not act as a short-circuited winding linking the core. It follows then that, during resetting, switch *A* should be open and switches *B* and *C* closed.

During intervals of zero input voltage, switches *A* and *C* may be either open or closed since no voltages exist in these circuits during such intervals. Switch *B*, however, must be open since the resetting battery would otherwise be applied to the resetting winding causing premature resetting to take place.

It should be noted that switch *C* is required to permit all current flow in one direction and block all current flow in the opposite direction; therefore, a simple diode will serve adequately the purpose of this switch. Switches *A* and *B*, however, are required to both block and permit current flow in the same direction, depending upon the circuit operation being performed at a given time. Simple diode elements will therefore not perform the functions required of switches *A* and *B*.

A PRACTICAL PULSE-INTEGRATING CIRCUIT

IN THE CIRCUIT shown in Fig. 3, transistors A and B perform the functions of switches A and B respectively of Fig. 2, while the diode in the output circuit performs the function of switch C. In this circuit, input voltage pulses are supplied through a transformer having two secondary windings in order both to apply voltage to the input circuit and also to apply, simultaneously, the appropriate driving voltage to the base of transistor A.

It has been shown[1] that a junction transistor can function as a nearly ideal switch between its emitter and collector electrodes if appropriate driving voltages and currents are applied to the base electrode. The pertinent conditions may be summarized for p-n-p transistors as

1. With the base positive with respect to both the emitter and collector the transistor acts as an open switch, permitting only a very small leakage current to flow in the emitter–collector circuit.
2. With the base negative with respect to either the emitter or collector the transistor acts as a closed switch, offering very low resistance to current flow in the emitter–collector circuit.

During application of an input pulse, the polarities of voltages existing on the various windings of the transformer and saturable core are as shown in Fig. 3. The voltage induced in winding N_a is of such polarity as to drive the base of transistor A negative with respect to its emitter and thus permit current flow from emitter to collector. The input pulse voltage induced in N_s is thus applied directly to winding N_i of the saturable core, the value of resistor R being such that the voltage drop of the core magnetizing current is negligible. As a result of the voltage applied to N_i, voltages are induced in windings N_b and N_h as shown. The voltage induced in N_b adds to the existing voltage applied to the base of transistor A to render it conducting, while the voltage induced in N_h adds to the bias voltage E_b applied to the base of transistor B to hold it blocking. The output diode, meanwhile, blocks the voltage induced in N_o from the output terminals. Thus the conditions specified for the input pulsing interval are fulfilled; switch A is closed while switches B and C are open.

During intervals between input pulses, no voltages exist on any of the windings of the saturable core. During this time the bias battery in the base circuit of transistor B holds it blocking, thus preventing the application of the resetting voltage E_r to winding N_r. It may be noted also that any negative input pulses will be blocked from the input winding by transistor A since the voltage induced in N_a will be of a polarity to block A rather than rendering it conducting as is the case with a positive input pulse.

Upon saturation of the core during some input pulse, the induced voltages in the saturable core disappear and the pulse voltage appears across resistor R. This voltage, which also appears in the base circuit of transistor B, overcomes the bias battery voltage, placing a negative potential on the base of B and causing it to cease blocking. The resetting voltage E_r is thus applied to N_r and resetting of the core is initiated. During resetting the polarities of voltages existing in the circuit are as shown in Fig. 4.

The voltage induced in N_b is of such a polarity as to place a positive potential on the base of transistor A, thus blocking current flow in the input circuit. The voltage induced in N_h, on the other hand, is of the polarity to hold transistor B conducting, thus insuring complete resetting of the core to negative saturation. The output voltage pulse induced in N_o during resetting is passed by the diode and a signal appears at the output terminals. Thus, all conditions specified for the resetting interval are met; switch A is open while switches B and C are closed.

It may be noted in Figs. 3 and 4 that the resetting transistor is used in an inverted connection; i.e., when acting as an open switch the collector is positive with respect to the emitter. This connection is used here in preference to the normal one to minimize leakage current during blocking which might otherwise cause partial resetting in the intervals between input pulses and result in inaccurate counting.

A FIXED TIME DELAY DEVICE

As pointed out previously, the pulse-integrating circuit functions as a preset counter if supplied with input pulses of constant volt-time area, and a preset time delay if these pulses are synchronous with a fixed-frequency source. A saturating transformer driven from a fixed-frequency source would provide such pulses; however, to provide more nearly ideal switching of the transistors, a rectangular input pulse is desirable.

The pulse-shaping circuit shown in Fig. 5 produces, in response to an input pulse, a rectangular output pulse of fixed volt-time area. Suppose that initially the saturable core has been reset to negative saturation under the influence of E_p acting on winding N_r through resistor R. The transistor is held in the blocking state by the bias voltage E_b applied to its base. An input pulse of the polarity shown overcomes the bias voltage, rendering the transistor conductive and applying E_p directly to winding N_p. Since the transistor emitter–collector circuit represents a much lower impedance than R (on a common turns base), the core is driven toward positive saturation, the voltage induced in winding N_h acting to hold the transistor conducting until the core saturates. The rectangular voltage pulse induced in the output winding N_o during this time has a fixed volt-time area determined by the saturation flux of the core and the number of output-winding turns. Upon saturation of the core the induced voltages disappear and the transistor again blocks. The core is then reset through the N_r circuit in preparation for the next input pulse, the diode in the output circuit blocking the induced voltage during resetting from the output terminals. Thus, in response to a rather arbitrary input pulse, the pulse-shaping circuit delivers a unidirectional rectangular pulse of fixed volt-time area.

In combining a pulse-shaping circuit and a number of cascaded counter stages, output windings of the preceding stage serve as the transformer secondary windings shown as the input in Figs. 4 and 5. Furthermore, the output diode is necessary only in the last stage since the input transistor of the succeeding stage serves this purpose as well as its other switching functions. In such a series of cascaded stages, each is isolated from the others by virtue of the solely

magnetic coupling. Therefore, regardless of the number of stages, only one common d-c power supply is required in the circuit.

The use of a saturable-core pulse shaper and the means employed to derive output pulses from the counter stages provide an important stability feature when a pulse shaper and several stages are operated in cascade; e.g., in order to obtain long time delays. The saturation flux of saturable magnetic cores varies somewhat with temperature; this variation becomes quite appreciable when wide ambient temperature variations, e.g., −65 to +70 C, are considered. Thus, if input pulses of truly constant volt-time area are applied to a counter stage, the number of pulses required to drive the core from negative to positive saturation will vary with ambient temperature, introducing inaccuracy in the time delay. However, by using the swing of a core from saturation to saturation to determine the volt-time area input to each stage, as is done in the circuitry described, no inaccuracy will be introduced if all cores (pulse shaper and counter stages) vary in a like manner with temperature. Since, in general, all cores will be of the same material, this will be quite nearly the case. Furthermore, since transistors are used in such a manner that they exhibit quite negligible voltage drops when conducting and very small leakage currents when blocking, wide variations in transistor characteristics, both between units and with temperature, may be tolerated without affecting the operation of the circuit. The net result of these considerations is that accurate and reliable operation, unaffected by wide ambient temperature variations, is obtained.

EXPERIMENTATION

Time-delay units have been built up consisting of a pulse shaper and two cascaded counter stages as shown for example in Fig. 6. In this unit a somewhat different method of detecting saturation of the counter core is employed than shown in Figs. 3 and 4. Instead of using the voltage developed across a series resistor upon saturation of the core to trigger the resetting transistor, the voltage induced in the resetting transistor holding winding (N_h of Figs. 3 and 4), as the core flux drops from its maximum saturated value back to the residual value at the end of the input pulse, is employed. Furthermore, the function of winding N_a of Figs. 3 and 4 is performed in the circuit of Fig. 6 by other windings, in addition to their other functions. On the pulse-shaper core the series combination of windings N_s and N_a is used, while on the first counter core windings N_o and N_h are used. This is possible since the method of saturation detection employed here eliminates the necessity for the resistor common to the input circuit and the resetting transistor base circuit of a counter stage, also enabling the common bias voltage to be used as a blocking bias in the base circuit of the counter-stage input transistor of Fig. 6. This bias voltage insures more complete blocking of the input transistor, especially under conditions of high ambient temperature. Despite these changes, however, the operation of the circuit is essentially the same as that described in the preceding section.

The unit shown in Fig. 6 is designed to require ten input pulses to saturate each stage; thus 100 input pulses are required to saturate the last stage and yield an output pulse. The saturable cores used in the circuit are all wound toroids of 2-mil Hipernik V material. All transistors are Westinghouse type *2N56 p-n-p* junction.

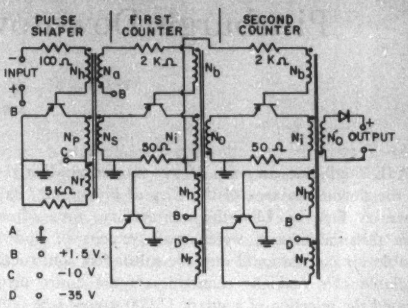

Fig. 6. Pulse-shaper and 2-stage preset counter circuit

Using input pulses derived from the 60-cycle power line, the unit was checked for operation over an ambient temperature range of −65 to +80 C. In all cases, 100 input pulses were required to obtain an output pulse from the second stage. Because of the digital nature of the device, it is expected that such absolute accuracy would be carried through to units of many more stages and, consequently, much longer time delays.

In order to check the retention of information (existing counter core flux level) over long periods of time, input pulses were turned off after some number less than 100 were supplied and then turned on again after intervals up to 8 hours. It was found that, despite the elapsed time, the proper total number of input pulses produced an output signal. These results indicate that, by cascading stages, time delays in excess of 8 hours should be obtainable with an accuracy of considerably less than one half-cycle of the input pulse frequency.

CONCLUSION

Circuitry employing junction transistors and rectangular-hysteresis-loop magnetic cores enables effective utilization of the voltage-integrating capabilities of the core to perform preset counting operations. An example has been given of an application of such circuitry in a fixed time-delay device to provide very long delays to an accuracy of a small fraction of the period of the fixed-frequency source from which it is driven. The components and circuitry used are such that reliable operation is obtained over wide ambient temperature ranges and with wide tolerances on power-supply voltage variations. The device is expected to display the excellent reliability and life which are characteristic of its components—junction transistors and saturable magnetic cores.

REFERENCE

1. The Use of Junction Transistors as Switches to Obtain Reliability, Interchangeability, and the Satisfaction of Military Environmental Conditions, R. L. Bright. AIEE *Transactions*, vol. 74, pt. I, March 1955, pp. 111–21.

Pittsburgh Downtown 69-Kv Power Supply

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MEMBER AIEE

THE single-line diagram of the substation desired for the downtown area of the City of Pittsburgh, Pa., is shown in Fig. 1. Like the metropolitan area of most cities obtainable sites were small, expensive, and not suitable for conventional outdoor substation construction. Available sites and the economics of the entire project dictated the selection of a site of 17,000 square feet.

Consideration was given to installing all equipment indoors, but discarded because of cost and required space. Metal-enclosed bus was investigated for the 69-kv portion of the station. Such equipment, without a specified impulse level, had been used previously by the industry. Unfortunately, system characteristics required standard 69-kv insulation level equipment for this station, so an investigation was made as to the feasibility of obtaining such equipment without excessively large enclosures. After considerable testing in the laboratories of manufacturers and the Duquesne Light Company, it was determined that such a bus could be obtained.

Fig. 2 shows the station under construction. All of the 12-kv equipment, which is of the segregated-phase-type utilizing air circuit breakers, is housed in a 3-story masonry building. Adjacent to the building in barriered enclosures are located the main transformers and grounding resistors.

The 69-kv switchyard is separated from the transformer area by the entrance roadway. Air-blast-type isolated-phase circuit breakers are arranged in two rows with cable terminating manholes located between the rows. Isolated-phase line compartments containing potheads and clearance and grounding switches are located between the circuit breakers. All of the 69-kv compartments and bus are of the isolated-phase type. Standard 69-kv bushings are used as baffles to isolate the bus runs from major equipment.

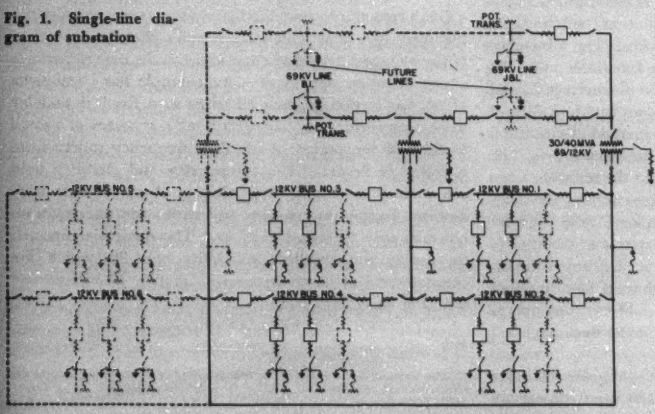
Fig. 2. Substation under construction

Located at the opposite end of the site from the main building is the oil-pumping plant for the pipe-type cable. This building is of masonry construction and forms a part of the enclosing wall that surrounds the site.

Station service power is supplied by small transformers provided as an integral part of the main power transformers. Compressed air for the operation of the circuit breakers and bleeding air for the 69-kv breakers is provided by a centralized air supply system. The major components are three water-cooled 1,000-pounds-per-square-inch (psi) compressors and two air storage units. Reducing valves are used to supply air at 260 and 150 psi for the circuit breakers.

The station is designed for complete remote control. It permits the use of higher voltages in compact totally enclosed installations at load center areas. Satisfactory appearance and safety were obtained without resorting to a building for complete enclosure of the station.

Fig. 1. Single-line diagram of substation



Digest of paper 55-226, "Pittsburgh Downtown 69-Kv Power Supply, Part II, Substation," recommended by the AIEE Committee on Substations and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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Rapid Measurement of Impedance and Admittance

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THE INCREASING tempo of development and application of linear networks of all kinds has created a pressing need for impedance- and admittance-measuring apparatus with which results can be obtained rapidly and directly over wide and continuous ranges of frequency.

Apparatus for automatic or manual measurement of the real and quadrature components of driving-point or transfer impedance and admittance has been developed for use in the video-frequency range of 50 kc to 5 mc. Driving-point impedance only will be discussed here.

The driving-point impedance of a linear network is a complex quantity whose real component, the resistance, is given by the expression $(V/I)\cos\theta$, and whose quadrature component, the reactance, is given by $(V/I)\sin\theta$. Here V is the amplitude of the sinusoidal voltage found at the driving-point terminals of the network when a sinusoidal current of amplitude I is impressed through those terminals, and θ is the difference in phase between the voltage and the current. It is apparent that if I is kept constant as the source frequency is varied, the resistance and reactance are proportioned to $V\cos\theta$ and $V\sin\theta$, respectively.

The latter quantities can be measured with a mixer of the kind used for frequency conversion in radio receivers. The mixer local oscillator voltage is derived from the current through the impedance, while the voltage across the impedance is used as the signal voltage. Since these voltages have the same frequency, application of the signal voltage to the mixer produces a change in the d-c output of the mixer proportional to $V\cos\theta$. This change is used to measure the resistance. If the relative phase of the signal and local oscillator voltages is shifted 90°, application of the signal voltage produces a change proportional to $V\sin\theta$, which is used to measure the reactance.

The apparatus used for measuring the driving-point impedance is shown schematically in Fig. 1. A variable video-frequency source of sinusoidal voltage, the amplitude of which is automatically controlled, is connected in series with a resistor r to the unknown impedance Z. The value of r is 100 times greater than the maximum value of the impedance range used; the current I through Z, therefore, is limited by r and is essentially independent of Z. The small voltage IZ developed across Z is used as a signal voltage. The relatively large source voltage V is used as local oscillator voltage.

The apparatus functions as follows: The signal voltage is amplified, amplitude-modulated at an audio frequency, and then applied to two mixers. Amplitude modulation of the signal voltage is introduced to eliminate error caused by slight variations in the amplitude of output of the video source. The local oscillator voltage is applied directly to one of the mixers, and also phase-shifted by 90° and applied to the second mixer. The amplitudes of the a-f output components of the first and second mixers are proportional to the magnitudes of real and quadrature components of Z, respectively. To obtain the signs of the components, as well as their magnitudes, a constant reference voltage of modulating frequency is added to the a-f output of each of the mixers, and the resultant voltages are demodulated. The d-c output of the demodulator which follows the first mixer is a measure of the real component of Z; that from the demodulator which follows the second mixer, of the quadrature component of Z.

A typical impedance plot obtained with the apparatus is shown in Fig. 2. It resulted from the measurement of a parallel resonant circuit consisting of a 6,000-micromicrofarad capacitor in shunt with a 7-microhenry inductor which had a Q of 30 at the resonant frequency of the circuit.

Digest of paper 55-211, "Rapid Measurement of Impedance and Admittance," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Communication and Electronics*, 1955.

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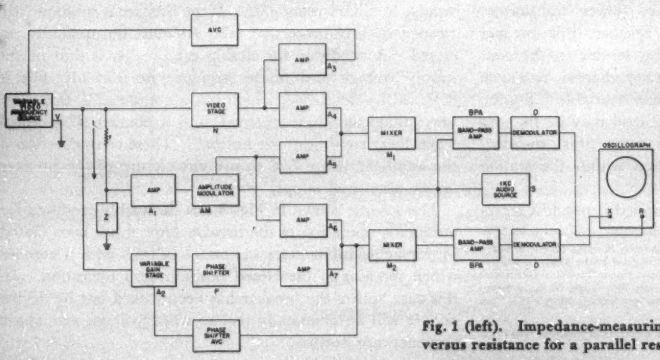

Fig. 1 (left). Impedance-measuring apparatus.

Fig. 2 (right). Reactance versus resistance for a parallel resonant circuit

Basic Circuitry for Pipe-Line Pump Stations Under Remote Control

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Sequence control actuated by push buttons has been widely employed for electrically powered crude-oil pipe-line pump stations during recent years, and it has been helpful in the development of today's remotely operated unattended pumping stations. Basic circuitry and various considerations are presented.

THROUGHOUT the last decade there has been an increasing trend to employment of sequence control systems in electrically powered pump stations on crude-oil and products pipe lines. Many of these sequence control systems are now being remotely initiated. From experience there have evolved certain desirable sequence practices which will be treated in the following discussion.

ELECTRICAL ELEMENTS

A TYPICAL single-line electrical diagram for a simple single-unit pumping station is shown in Fig. 1; the piping and valve arrangement are shown in Fig. 2.

The primary disconnecting switch, lightning arresters, and transformers, usually owned by the electrical utility company, are located in an outdoor substation which serves the pump station at an appropriate voltage, ordinarily 2,300 or 4,160 volts depending on the size of the load. The pipe-line company usually installs a set of main secondary disconnecting switches to provide isolation of the station from the power supply.

The scheme shown employs a main circuit breaker *52* located outside the station building and the hazardous area. The principal control equipment is installed in a pressurized room of the station. For safety the station ventilation is operable even when the main breaker is open. By connecting the auxiliary power transformer on the supply side of the main breaker, this breaker may be opened without interrupting service to the control room and pump room fans, battery charger, and such lighting as is desired to be continuously available. Station isolating valves and local residential load may be likewise served. All equipment supplied from this so-called "essential" auxiliary bus and located within the station building is explosion-proof.

The remaining auxiliaries are supplied through a segregating breaker *52N*. Their control equipment is installed in the pressurized control room along with the main pump control. Breaker *52N* is arranged for tripping simultaneously with the main breaker *52* in an emergency such as might cause the control room atmosphere to become hazardous.

The main breaker feeds the pump unit (or pump unit bus) and typically is equipped with relaying for phase reversal and voltage failure *47*, overcurrent *51S*, and with a voltmeter *V* and a wattmeter *W* to indicate power supply and load conditions. An operating transformer on the supply side of the breaker furnishes power for breaker closing, and a battery furnishes direct current for breaker tripping. The main breaker has connected to its load side the main pump motor starting equipment, with surge protection capacitor and arrester.

In a single-unit station employing full-voltage starting of the main unit, the layout shown in Fig. 1 may be modified by combining the main breaker function with the motor breaker, thereby eliminating a breaker. Some installations, particularly new stations designed for unattended operation, have all the control equipment installed in a single location sufficiently separated from the pumping equipment proper to be outside of the hazardous area. With this arrangement, no hazard is introduced in the control room when its ventilation is interrupted, and the segregating breaker *52N* is omitted.

MAIN BREAKER CONTROL

THE MAIN circuit breaker may be manually controlled either locally or remotely. Fig. 3 shows a scheme, in which momentary contact *1-CLOSE* of master control device *1* energizes the breaker-closing relay *52X* through contacts of station lockout relay *86S* and a phase reversal and undervoltage auxiliary relay *47X*. If the breaker is subsequently tripped by any protective relay, it must be manually reclosed. A condition for closing the breaker is that power supply voltage and phase sequence be normal; this is detected by device *47*, which has a contact *47L* closed on low voltage or phase reversal, and a contact *47N* closed when these conditions are normal. These contacts control the auxiliary relay *47X* to prevent closure of the breaker under abnormal supply voltage.

The scheme shown in Fig. 3 can be readily modified for automatic operation of the breaker after it has been closed by replacing momentary contact *1-CLOSE* with a contact which remains in the closed position after operation. In this case, unless the breaker has been locked out by device *86S*, it will automatically reclose when voltage and phase sequence are normal.

Revised text of paper 55-63, "Basic Circuitry for Electrically Powered Pipe-Line Pump Stations Under Automatic or Remote Control," recommended by the AIEE Committee on Petroleum Industry and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Published in AIEE *Applications and Industry*, March 1955, pp. 4–14.

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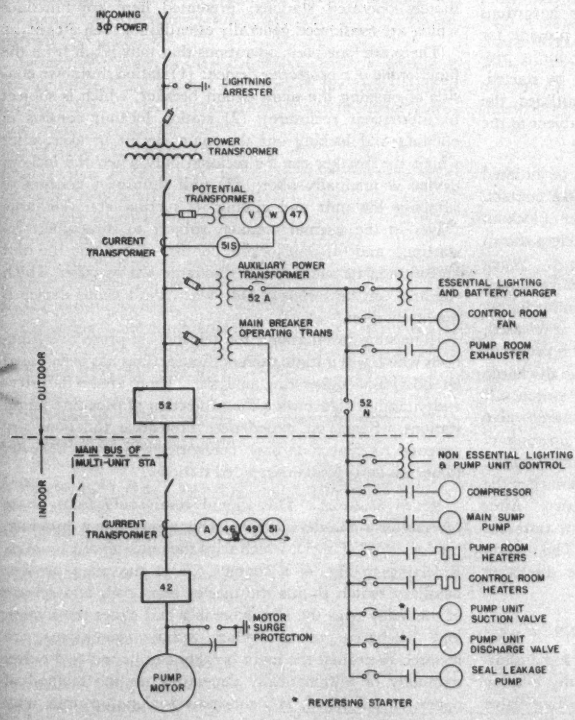
PUMP UNIT CONTROL

A TYPICAL scheme is shown in Fig. 4 for starting and stopping a single-unit station, as in Fig. 2, with sequence operation of the unit suction and discharge valves and a solenoid-operated valve for venting the pump, as well as an associated pump-room exhaust fan.

Whether operation is entirely manual or by automatic sequence, the operating procedures should be carried out in prescribed order. For starting: (1) open suction valve and start necessary ventilation equipment; (2) energize pump motor; and (3) open discharge valve and close pump venting valve. For stopping: (1) de-energize pump motor and its associated ventilation equipment; (2) close discharge valve; and (3) close suction valve. There are individual variations from these procedures; for example, many installations do not require venting, and others in stopping the unit close the suction and discharge valves simultaneously.

Fig. 4 applies to an installation where ventilation is required to remove the motor loss heat, as for an explosion-proof motor located in the pump room. In this case, an air intake should be provided in the wall opposite the motor, and an exhauster driven by an explosion-proof motor should be installed in the wall opposite the pump; this is of course unnecessary for motors located outdoors.

Starting Sequence. The starting signal originates with momentary closure of master element *1-START* contact, which can be a contact of a local push button, an automatic pilot device, or a remotely actuated relay. In series with this contact is limit switch contact *20D4* to prevent starting the unit when the discharge valve is in other than the closed position. This is desirable to reduce the starting load on the motor. When the *1-START* contact closes the circuit through *20D4*, master relay *4* seals itself in, starts the unit exhaust fan by energizing its contactor *88EC*, and prepares a circuit to energize the *OPEN* contactor *20S0* of the suction valve controller. This circuit is completed through an auxiliary switch on the exhaust fan contactor *88EC*. If desired, a vane switch or auxiliary contact on the exhaust damper may be used instead of a contact of the exhaust-fan contactor *88EC*. At the end of the opening stroke *20S0* is de-energized by the opening of limit switch *20S1* on the valve mechanism. Closure of relay *4* sets up a circuit for energizing solenoid vent valve *20V*, and as the suction valve leaves its closed position, closure of limit switch *20S3* energizes the vent valve solenoid to open the vent valve. The vent-valve solenoid is subsequently de-energized, closing the vent valve, by the opening of limit switch *20D4* when the discharge valve leaves the closed position. Closure of relay *4* prepared a circuit for energizing relay *42X* of the pump motor breaker, which circuit is completed through limit switch contact *20S2* when the suction valve



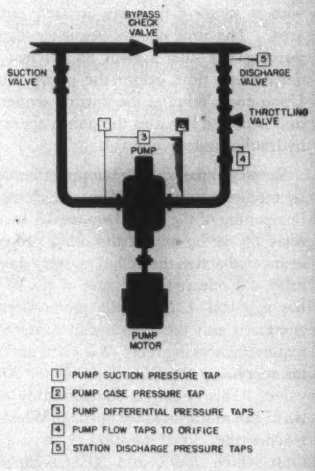


Fig. 1 (left). Typical single-unit pump station. Fig. 2 (above). Piping and valve arrangement for simple single-unit pump station

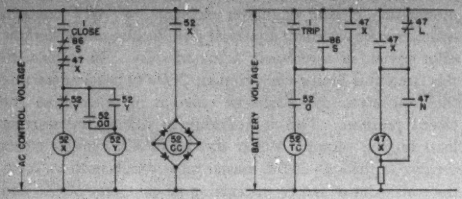


Fig. 3. Control of main circuit breaker of pump station

reaches the open position. Closure of relay *42X* causes the breaker to close.

When the breaker closes, an auxiliary switch *42a* closes to energize the *OPEN* contactor *20DO* of the discharge-valve controller, and at the end of the opening stroke *20DO* is de-energized by the opening of limit switch *20D1* on the valve mechanism. The pump unit is then in operation.

A sequence completion check is initiated when master relay *4* is energized, completing a circuit to timing relay *48*, which is set to provide sufficient interval for normal completion of the starting sequence. If, at the termination of this interval, the suction and discharge valves are not in the full open position and the exhaust fan contactor is not closed, the unit is shut down through lockout relay *86*. See Fig. 5 and later discussion of protection.

When the pump motor is force-ventilated, is it equipped with a motor-driven fan located outside the hazardous area. The unit control sequence then must provide for purging the duct system and motor housing for a predetermined time before the pump motor can be started. Upon completion of the starting sequence, as outlined, the unit is on the line and the pump operation is subject to the hydraulic system control.

Stopping Sequence. The stopping sequence can be initiated by momentary closure of master element *1-STOP* contact, by opening of the main breaker *52*, by operation of lockout relay *86*, or by any of the other protective devices shown connected across the coil of master relay *4* in Fig. 4. When relay *4* is released by closure of any of the contacts shown, the trip coil *42TC* of the motor breaker is immediately energized and the exhaust-fan contactor *88EC* is released, sequence checking relay *48* is reset, and a circuit is prepared for energizing the *CLOSE* contactor *20DC* of the discharge valve. This circuit is completed by auxiliary switch *42b* when the motor breaker opens. When the discharge valve reaches the closed position, it is stopped by opening of limit switch *20D3*, and *20D4* completes a circuit to the *CLOSE* contactor *20SC* of the suction valve. Closure of the suction valve completes the stopping sequence. After initiation of a stopping signal the unit cannot be restarted until the discharge valve is completely closed. The suction valve cannot be opened or closed unless the discharge valve is fully closed.

FEATURES OF MULTIUNIT STATIONS

Use of two or more pump units introduces some additional considerations. Multiunit stations usually employ pumps connected in series with a single throttling valve on the downstream side of the final pump. Time-delay undervoltage relays may be applied to the individual units with progressive time settings so that, following a voltage dip, as many units can be retained on the bus as practical, consistent with reasonable current demand.

In multiunit stations, shutdown in response to abnormal pressures is desirably sequential; to minimize hydraulic shock and to keep as much of the station in operation as practical when shutting down part of the units would result in correction of the abnormal pressure. Shutdown caused by low suction or high case pressure in the individual pumps is accomplished in the same manner as for a single-unit station, by pressure switches installed on each side of each unit. Shutdown caused by high station discharge pressure must be actuated by a single pressure switch tapped to the downstream side of the station throttling valve. In many stations this switch shuts down all units simultaneously. However, sequential shutdown on high station discharge pressure can be accomplished.

PROTECTION

In all types of electric equipment installations, protection against abnormal operation or equipment failure is important; however, in no type of installation is an adequate protective system more important than in a pipe-line pump station because of the hazardous nature of the medium transported. This is particularly true for remotely operated stations; presented here are functions which are considered generally essential for such a case.

There are four basic operations that may result from the functioning of a protective device: (1) station shutdown consists of opening the main circuit breaker, which is subject to subsequent reclosure; (2) station lockout consists of opening and locking out the main circuit breaker, after which the breaker can be reclosed only when the lockout device is manually reset; (3) unit shutdown consists of stopping the unit and closing its suction and discharge valves in the normal manner, subject to subsequent restarting; and (4) unit lockout consists of stopping the unit and closing its suction and discharge valves, after which the unit can be restarted only when the lockout device is manually reset.

In existing installations, the selection of protective functions which will initiate each of these actions has been based on individual engineering analysis. There are no industry-wide standards governing the protection of pipe-line pump stations. Based on experience, protective functions are assigned to these four basic categories which are believed to be best for typical unattended stations.

Station Shutdown. This should result only from phase reversal or a-c undervoltage. This protection is provided by device *47* (Fig. 1), which trips the main circuit breaker. Referring to Fig. 4, a contact *52b* of the main breaker auxiliary switch shunts the master relay coil, and release of this relay trips the motor breaker and closes the suction and discharge valves. When voltage conditions are restored to normal the main breaker can be reclosed either manually or automatically depending on the method of operation employed, and the individual pump units may

then be restarted after their suction and discharge valves have closed.

Station Lockout. The following conditions should result in station lockout: (1) a-c overcurrent, *51S;* (2) battery undervoltage, *80;* (3) low instrument air pressure, *96;* (4) high level in main sump, *63L1;* (5) unsafe atmospheric condition in control room, *97* or *98* (applies only where control room is subject to hazardous atmosphere).

Referring to Fig. 5, all of these functions result in operation of station lockout relay *86S*, a contact of which trips the main breaker *52*. This results in releasing the master relay *4* of each individual pump unit, as described in the preceding section. In the case of the first four functions listed, the auxiliary power is not interrupted, and release of master relay *4* is followed by tripping of the pump unit breaker and closure of the discharge and suction valves. However, in the case of the fifth function, closure of device *97* or *98* contact results in tripping of auxiliary segregating breaker *52N* simultaneously with energization of lockout relay *86S*. After this lockout operation, reclosure of the main breaker can only be accomplished when relay *86S* has been manually reset. The auxiliary segregating breaker *52N* must be manually closed.

Unit Shutdown. The following conditions should result in shutdown of an individual pump unit: (1) low suction pressure, *63P1;* (2) high pump case pressure, *63P2;* (3) high discharge pressure, *63P5;* (4) motor overtemperature, *49;* (5) pump case overtemperature, *26P;* and (6) motor phase-current unbalance, *46*.

Occurrence of any of these conditions results in release of master relay *4* and normal shutdown of the pump unit as shown in Fig. 4. In the case of low suction pressure protection, note that device *63P1* has its contact in series with a limit switch *20S2*. This is necessary to prevent functioning of the low suction pressure switch until the suction valve is fully open, at which time normal suction pressure should ordinarily exist.

Following such shutdowns, the unit can be restarted by reclosure of the *1-START* contact.

Unit Lockout. The following conditions should result in unit lockout: (1) motor overcurrent, *51;* (2) incomplete starting sequence, *48;* (3) seal failure, *63L3;* (4) motor bearing overtemperature, *38M1, 38M2;* (5) pump bearing overtemperature, *38P1, 38P2*.

Referring again to Fig. 5, all of these functions result in operation of pump unit lockout relay *86*, a contact of which shunts the master relay *4*. The release of master relay *4* results in the tripping of the pump unit breaker and closure of the discharge and suction valves. The unit cannot be restarted until lockout relay *86* has been manually reset.

The incomplete sequence protection is initiated by timing relay *48*, energized when master relay *4* closes. After its time setting interval, contact *48* closes in the coil circuit of auxiliary relay *48X*. If at this time both the suction and discharge valve limit switches do not indicate the fully open position, or if the contactor *88EC* of the exhaust fan is not in its normal closed position, a circuit is established to energize auxiliary relay *48X* which in turn energizes lockout relay *86*. If during running operation either valve or the exhaust fan contactor leaves its normal position, relay *48X* is energized and lockout results. Where the pump motor is force-ventilated the contact of device *88EC*, in the coil circuit of auxiliary relay *48X*, is replaced by a contact of the air-flow switch *88F*.

Local Annunciation. It is desirable that all protective functions be individually annunciated locally. In attended stations this annunciation frequently takes the form of an audible alarm in combination with identifying indicating lights appropriately arranged on a graphic control panel. At a remotely controlled station the most satisfactory form of annunciator is the drop type. All of the protective devices discussed in this article are shown connected to individual drops of an annunciator in Fig. 5. With the type of annunciator shown, closure of any protective device contact completes a circuit to the coil of an individual drop *30-1*, etc., in series with the operate coil *30-0* of a latching element of the annunciator. When the operate coil is thus energized, contact *30-0* of the latching element closes

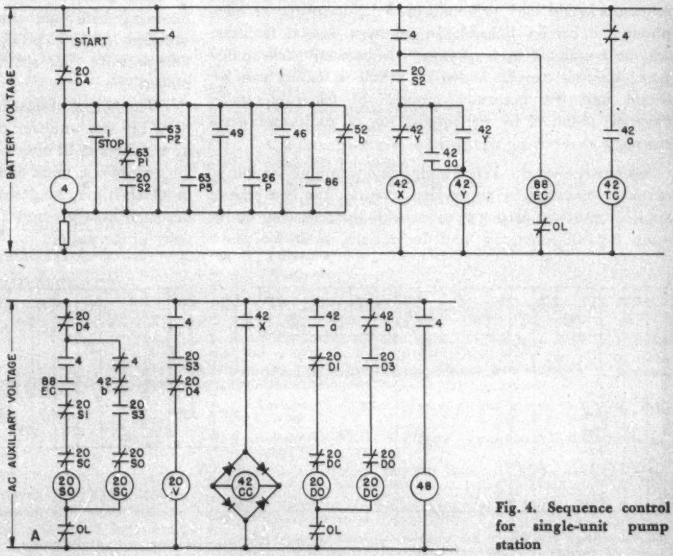


Fig. 4. Sequence control for single-unit pump station

to increase the current through the individual drop to cause it to operate and open its coil circuit. A second contact *30-0* can be used to sound a bell, or it can initiate a remote alarm. The alarm circuit is restored to normal by energization of coil *30-R* which mechanically resets the latching element.

REMOTE OPERATION

THE unattended remote operation of both single-unit and multiunit pump stations is becoming quite prevalent.[1-3] Such remote operation can be advantageously obtained by the use of supervisory control and telemetering equipment. Supervisory control operating over a single telegraphic-type channel is used to perform the necessary operations, to provide indications of the position of apparatus, and to provide indications and alarms for trouble conditions. Telemetering equipment is used to provide quantitative indications of hydraulic and electrical conditions at the unattended station. The telemetered indications can be obtained continuously by the use of a separate channel for each indication, or selectively over the supervisory control channel. In addition, multiplexing techniques can be employed to connect the telemetering transmitters and receivers to the same channel in consecutive order.

In general, remote operation of a pump station is not effected from a location closer than an adjacent attended pump station. An increasing trend is the establishment of centralized control locations, such as the initial station or the pipe-line system dispatching office, from which large numbers of unattended stations can be operated. Therefore, the remote operation must be effected over relatively long distances ranging from approximately 20 miles to hundreds of miles. The necessary channels for operation of pipe-line pumping stations can be provided by telegraphic-type tones operating over privately owned microwave or telephone-line carrier links.[4,5] In addition, leased facilities can be employed in two ways.[6] Individual telegraphic-type channels can be leased or a voice channel can be leased and the necessary number of telegraphic-type channels obtained by the application of audio-tone generating and receiving equipment.

Supervisory Control. When a pipe-line pumping station is remotely operated by supervisory control, the equipment applied must be arranged to provide the following minimum control functions, and indications of device positions: (1) start-stop sequence control of each pump unit; (2) indication of stopped or running condition of pump motors; and (3) indication of open, closed, and intermediate positions of the suction and discharge valves of all pump units.

In addition, it is extremely desirable to provide an indication of the position of the main circuit breaker (also control of main breaker unless it is completely automatic), and to provide indications of station lockout and individual pump unit lockout. A supervisory control cutoff or transfer switch is desirable at the controlled station, and it is usual to indicate position of this switch at the controlling location. There may be installations where it is desirable to control the main sump pump. Unless completely automatic means are provided, it may be necessary to provide for remote adjustment of the control point setting of the station discharge pressure controller. Where electrically operated isolating valves are employed, provisions for their remote operation may be desirable.

Economic considerations usually prohibit individual indications over supervisory control for all of the protective-device operaation. However, the protective devices can be grouped in various combinations to provide a relatively small number of indications which can assist in determining the type of personnel to be dispatched to the controlled station after lockout is reported. A typical grouping of functions for common indications for a single-unit station is (1) power failure: device *47;* (2) electric equipment failure: devices *46, 48, 49, 51S, 51, 80, 88EC;* (3) mechanical equipment failure: devices *26P, 38M1, 38M2, 38P1, 38P2, 63L1, 63L3, 96,* and *97* or *98;* and (4) abnormal hydraulic conditions: devices *63P1, 63P2, 63P5.*

Telemetering. Regardless of the number of pump units in a remotely operated station, it is essential to provide telemetered indications to the controlling location of the following hydraulic quantities: (1) initial pump suction pressure; (2) final pump discharge pressure; (3) outbound line pressure (not required if no throttling valve is employed).

Telemetering of flow may be desirable where flow conditions are not uniform throughout the line as may result from deliveries at intermediate points. While not essential for remote operation of a pump station, there are instances in which it may be desirable to telemeter electrical quantities such as watts and amperes for the pump motors and volts for the station.

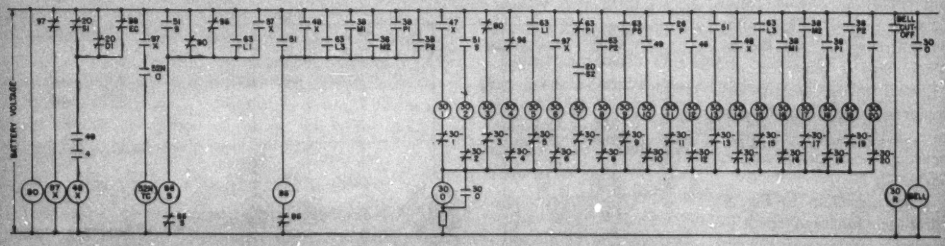


Fig. 5. Station and unit lockout and annunciation

As previously indicated, the telemetering may be continuous, the telemetered quantities may be indicated in consecutive order through some type of time-division multiplexing, or they may be selectively obtained at the will of the dispatcher through the supervisory control equipment. Economics usually dictates in favor of the latter two arrangements, but there are many compromise arrangements.

Pulse-duration or frequency-type telemetering systems are usually employed. The pulse-duration-type telemetering transmitters may be directly actuated by the hydraulic quantity or by the electric output of a transducer. The frequency-type telemetering transmitters can only be employed for hydraulic quantities through the use of transducers. The frequency-type telemetering system provides faster rate of response but requires channels capable of handling higher keying speeds.

CONCLUSION

MODERN electrically powered pipe-line pumping stations are the result of the technical advances in this field which have been made during a period of some 3 decades. The advent of push-button sequence control for such stations approximately 15 years ago was the forerunner of today's accelerating use of remotely operated unattended pumping stations. The justification for such remotely controlled pumping stations is purely economic.

Reliability cannot be overemphasized in the design of remotely operated stations. A full complement of devices to detect all hydraulic and electrical trouble conditions is all-important. Locally actuated shutdown of the unit or station in trouble should result after a condition of trouble has been detected by one of these protective devices. Remote or automatic operation should only be employed when its functioning is co-ordinated to an adequate protective system.

Heretofore there has been a lack of consistent practice in designating equipment devices for pipe-line pump stations. As the result of considerable investigation, designations have been used which were based on American Standards Association Standard *C37.2*,[7] with such adaptations as were deemed desirable for pipe-line use. It is strongly recommended that such a system be followed as standard practice to facilitate the interpretation of diagrams.

Appendix. Device Designations (Based on ASA Standard C37.2 for Automatic Switchgear)

1	Master element (start, stop, close, trip)
4	Master relay
20SC	Suction valve closing contactor
20S0	Suction valve opening contactor
20S1	Limit switch open only when suction valve is fully open
20S2	Limit switch closed only when suction valve is fully open
20S3	Limit switch open only when suction valve is fully closed
20DC	Discharge valve closing contactor
20D0	Discharge valve opening contactor
20D1	Limit switch open only when discharge valve is fully open
20D3	Limit switch open only when discharge valve is fully closed
20D4	Limit switch closed only when discharge valve is fully closed
20V	Vent valve
26P	Pump case overtemperature thermal device
30	Annunciator relay
	30-1, etc.—individual drops
	30-0—operate coil
	30-R—reset coil
38M1	Motor bearing thermal relay (inboard)
38M2	Motor bearing thermal relay (outboard)
38P1	Pump bearing thermal relay (inboard)
38P2	Pump bearing thermal relay (outboard)
42	Motor circuit breaker
	a—Auxiliary switch closed when breaker is closed
	aa—Auxiliary switch closed when operating mechanism of breaker is in energized or operating position
	b—Auxiliary switch open when breaker is closed
	CC—Closing coil
	TC—Trip coil
	X—Closing relay
	Y—Closing cutoff relay
46	Phase-current balance relay
47	Undervoltage or reverse phase-voltage relay
	L—Contact closed for abnormal conditions
	N—Contact closed for normal conditions
47X	Auxiliary relay for reverse phase-voltage relay
48	Incomplete sequence timing relay
48X	Auxiliary incomplete sequence relay
49	Motor thermal overload relay
51S	Station overcurrent relay
51	Motor overcurrent relay
52	Main circuit breaker
	a—Auxiliary switch closed when breaker is closed
	aa—Auxiliary switch closed when operating mechanism of breaker is in energized or operated position
	b—Auxiliary switch open when breaker is closed
	CC—Closing coil
	TC—Trip coil
	X—Closing relay
	Y—Closing cutoff relay
52A	Auxiliary power breaker
52N	Auxiliary segregating breaker
	TC—Trip coil
63L1	High main sump level switch
63L3	Seal failure contact
63P1	Low suction pressure switch
63P2	High pump case pressure switch
63P5	High discharge pressure switch
80	Battery undervoltage relay
86S	Station lockout relay
86	Pump unit lockout relay
88BC	Blower fan starter contactor
88EC	Exhauster fan starter contactor
88F	Motor air flow switch
96	Low instrument air switch
97	Low room air differential pressure
98	Hazardous atmosphere protective device
A	Ammeter
V	Voltmeter
W	Wattmeter

References

1. Remote Operation of Pipe-Line Pumping Stations, **W. A. Derr, M. A. Hyde.** AIEE *Transactions*, vol. 73, pt. II, September 1954, pp. 190–8.

2. Four Unattended Pipe-Line Pumping Stations, **R. S. Cannon, T. V. Bockman.** *Oil and Gas Journal*, Tulsa, Okla., December 7, 1953, pp. 101–03.

3. New Developments in Remote Control of Pumping Stations, **M. A. Hyde.** *Ibid.*, October 13, 1952.

4. Microwave Communication, **N. B. Tharp.** *Westinghouse Engineer*, East Pittsburgh, Pa., November 1952, pp. 198–203.

5. Microwaves for Pipeliners, Part VIII, Supervisory Control and Telemetering, **C. B. Loster.** *Pipeline News*, Bayonne, N. J., July 1953, pp. A1–A8.

6. Leased Channels for Metering and Control, **H. H. Joyner.** *Electric Light and Power*, Chicago, Ill., December 1953, pp. 100–06.

7. Automatic Station Control, Supervisory, and Telemetering Equipments. *ASA C37.2-1945*, American Standards Association, New York, N. Y., December 11, 1945.

Gamma Radiation Effects on Liquid Dielectrics

by T. D. CALLINAN

Gamma radiation can transform dielectric liquids by converting them into solids or by decomposing them into acids and gases. Various liquids can be evaluated; from the results obtained, the expected changes in them when used in equipment subjected to irradiation can be estimated. There are additives available which seem to increase the stability of such liquids subjected to gamma fields.

THE COMMERCIAL LIQUID DIELECTRICS of today have been developed over a period of 40 years to cool windings, store energy, and sustain high voltages at elevated temperatures in the presence of active metals. The efficiency of these liquids depends upon their inherent stability under operating conditions. Thus any substance which would increase in viscosity with time would endanger the heat-transfer characteristics of the equipment and lead to excessive temperatures and thermal failure. Again, rearrangement of the molecular structure would be expected to result in changes in the dielectric constant and loss factor of the substance and consequently of its energy storage characteristics. Finally, the excessive formation of gases or other regions of nonuniformity in the liquid would lead presumably to early breakdown and electric failure of the equipment at high voltages.

The successful industrial development of nuclear power necessitates using liquid-filled components in the vicinity of sources of intense gamma radiation. Due to photoelectric effects, Compton scattering, and ion-pair formation in substances in such fields, ionized and excited molecules, and free and atomic radicals are generated in commercial liquid dielectrics resulting in marked changes in the physical properties of the liquids.

Interest in this work from the viewpoint of a dielectrics specialist may be explained by saying that 10^9 roentgens cause transformer oil to yield 10 to 15 times its volume of gas, teflon to crumble to a powdery solid, and silicone grease to become a gritty gel. From studies on the deterioration of such compounds it is hoped that stabilizers may be developed and the rules for synthesizing stable compounds determined.

Gamma rays occur when the nucleus of an atom rearranges to a more stable condition. In the electromagnetic spectrum they appear at approximately 10^{20} cycles per second, i.e. higher in frequency than hard X rays.

Full text of conference paper CP55-103 presented at a session of the AIEE Committee on Basic Sciences, AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955.

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Among the radioactive isotopes giving pure gamma rays, those listed in Table I have considerable interest. It will be noticed that a wide range of half lives occur as well as large differences in the energies of the emitted photons. In considering operating conditions where irradiation might lead to deterioration of the dielectric, both the period of decay and the energy associated with the ray must be known, for variations in either the dosage or the absorption mechanism can produce different effects in the same substances.

The radiation which emanates from the radioactive cobalt arises from the radiative decay of the metal to a stable isotope of nickel. The steps involved in this process are shown in Fig. 1.

The 2,300-curie source of Cobalt 60 located at the Naval Research Laboratory was employed in these tests. A sketch of the facility is shown in Fig. 2. The radioactive cobalt is located at the bottom of the well under 12 feet of water to protect personnel against the rays. In the case of reactions induced by the radiation, which happens to be exothermic, the water also acts as a cooling medium; the amount of heat liberated by the source itself is insignificant. The procedure for irradiating materials consists in placing an ampoule or glass container in one or two cells which can be lowered into the radiation field. The field arises from Cobalt 60 sealed in stainless-steel cylinders, a sketch of which is shown in Fig. 3. These are located on a plate at the bottom of the well. The cells are watertight stainless-steel structures one of which rests in the most intense part of the field, and the other which fits concentrically outside the source. A phantom illustration, Fig. 4, shows this arrangement.

The principal mechanism by which the gamma radiation from Cobalt 60 transforms organic substances in its path is by Compton scattering. By this is meant the collision of the gamma photon with an electron so as to hurl the electron out of the original molecule's orbit and through the

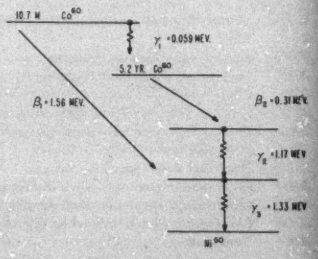
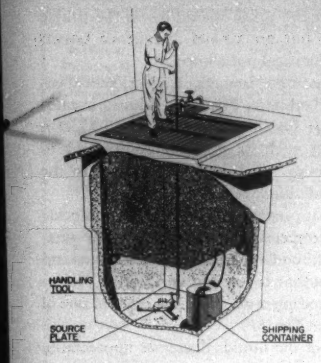


Fig. 1. Radioactive decay scheme of Cobalt 60



COBALT 60 SOURCE

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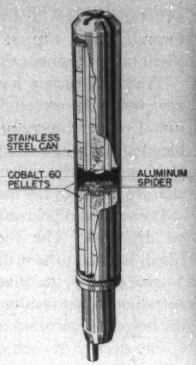


SOURCE CAN

3

4

Fig. 2. Sketch of the 2,300-curie Cobalt-60 source at the U. S. Naval Research Laboratory. Fig. 3. Cobalt-60 pellets in stainless steel cylinder (source can). Fig. 4. Phantom representation showing the container wherein the samples are irradiated

galaxy of other orbital electrons. In this case the gamma photon continues through the liquid but possesses less energy, whilst the electron excites and perturbs as many as 100,000 molecules near which it passes. Thus the changes in liquid dielectrics are the changes caused by secondary electrons.

In an organic material which finds itself in a field of intense-radiation ionized molecules, there are present excited molecules and free and atomic radicals.

The ionized molecules arise from forceful collisions of a gamma photon and an orbital electron which strips the molecule. This may be represented as:

$$M+\gamma \rightarrow M^{+}+e$$

Such molecules are known to have three characteristic properties, namely,

1. They combine with electrons to yield excited molecules according to the scheme:

$$M^{+}+e \rightarrow M^{*}$$

2. They combine with electrons to yield free and atomic radicals directly. This may be represented as:

$$M^{+}+e \rightarrow R^{0}+H^{0}$$

3. Ionized molecules sometimes degrade directly into molecules of lower molecular weight. Some ionized molecules split off hydrogen leaving as a residuum another ionized unsaturated molecule. This may be represented as:

$$M^{+} \rightarrow RCH=CH_2+H_2$$

On the other hand, chain rupture of ionized molecules is known to occur according to the scheme:

$$M^{+} \rightarrow RH+CH_4$$

Excited molecules are produced by the combination of an electron and an ionized molecule. Frequently the electron is a prodigal of the parent molecule. The total reaction may be represented as:

$$M^{+}+e \rightarrow M^{*}$$

The molecules have three properties of importance, namely,

1. They decompose spontaneously into free and atomic radicals according to the scheme:

$$M^{*} \rightarrow R^{0}+H^{0}$$

2. They suffer molecular rearrangement, straight chain compounds frequently reverting to branched isomers thus:

$$RCH_2CH_2R^{*} \rightarrow R_2CHCH_3$$

3. And finally they combine with free and atomic radicals to yield unsaturated compounds according to the scheme:

$$M^{*}+H^{0} \rightarrow RCH=CH_2+H_2$$

Besides the reactions already described, free and atomic radicals propagate new products, the ones of most importance being those resulting in unsaturated compounds.

These arise by two mechanisms

1. The interaction of a free radical and an atomic radical according to the representation:

$$R^{0}+H^{0} \rightarrow \underset{|}{RCH}=CH_2+H_2$$

2. And the interaction of a free or atomic radical with another molecule thus:

$$M+H^{0} \rightarrow RCH=CH_2H_2$$

The reason for listing in detail the mechanisms of the reactions is that they are the basis for suggestions on stabilizing present commercial items by the incorporation of additives.

PROPERTIES OF THE COMMERCIAL LIQUID DIELECTRICS

CHEMICALLY, mineral oil (transformer oil) is a mixture of hydrocarbons and varies with origin and refinement, but is in general composed of paraffins having the structure isomeric with $CH_3(CH_2)_{20}CH_3$ together with some napthenes (alicyclic hydrocarbons) having among others the structure shown in Fig. 5*A*. Unsaturates as well as a group of oxidation products known as the quinones, Fig. 5*B*, are also found in traces. It is from the substituted cyclics and the oxidation products that the small but measurable dipole moments arise. The properties of the transformer oil as well as the other liquids employed in these studies are listed in Table II.

Castor oil is a viscous liquid pressed mechanically from the naturally occurring castor bean. Among its components is glycerol triricinoleate, the structure of which is shown in Fig. 5*C*. Because of its ester nature it saponifies in the presence of water and an alkaline body to yield glycerin and salts of ricinoleic acid. The olefin bond is also a reactive one. It interacts with oxygen to yield degradation products and with similar molecules to yield cross-linked items and sludges. Castor oil contains three hydroxyl groups (secondary alcohols) capable of forming hydrogen bonds, and hence of yielding highly viscous bodies.

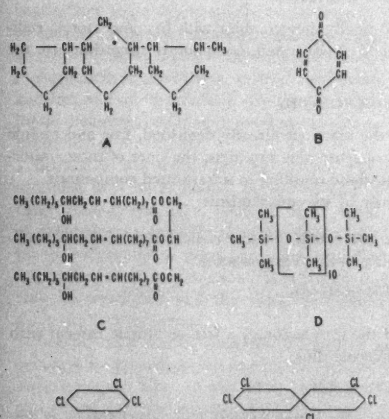
The silicone fluids are thermally stable synthetic metal-organic polymers of intermediate molecular weight prepared by the hydrolysis and condensation of dimethyl silicon dichloride or its analogues. The silicones resemble the paraffin hydrocarbons in transformer oil in that they are chemically chainlike polymers consisting of repetitive groups as shown in Fig. 5*D*. Changes in the properties have been effected by changing the number of repetitive units (fewer groups yielding oils of lower viscosity) and by replacing the methyl (CH_3) group with say a phenyl (C_6H_5) group. The structure of these molecules is not threadlike as the simple formula might suggest but are kinked and hence possess slight but permanent electrical unbalance.

Trichlorobenzene has three isomers, 1,2,4-trichlorobenzene being the one studied here, Fig. 5*E*. While it is a liquid at room temperature because it soldifies at 17 C, it is blended with materials such as pentachlorodiphenyl to yield more useful eutectics. This article is limited to the characteristics of the individual reagents.

Pentachlorodiphenyl is prepared by the action of chlorine on diphenyl. The commercial impregnant, when analyzed, is found to have the equivalent of 12 carbon atoms and 54 per cent of the material by weight is chlorine, corresponding to pentachlorodiphenyl. The structure of one of the isomers is pictured in Fig. 5*F*.

The density of each of the liquids decreases appreciably with temperature as shown in Fig. 6, but not all decrease at the same rate. The halogenated compounds are seen to possess densities over 1.5 times greater than those of the nonhalogenated compounds; hence they present to an incident photon a denser array of electrons leading to a higher absorption coefficient. In Fig. 7, the surface tension of the liquids have been plotted against temperature, this property having an important relation on the tendency of the gas to remain trapped in the liquid or to become expelled. The viscous pentachlorodiphenyl and castor oil are seen to have higher surface tensions than the silicone oil but all are considerably below the value of water (80 dynes per cm). The viscosities of the five commercial liquids have been plotted in Fig. 8. Trichlorobenzene is seen to be uniformly low, whilst pentachlorodiphenyl is seen to remain viscous throughout the range.

The dielectric constants and dielectric loss factors of the five commercial liquids, determined over the temperature range −60 to 120 C, are shown graphically in Figs. 9 and



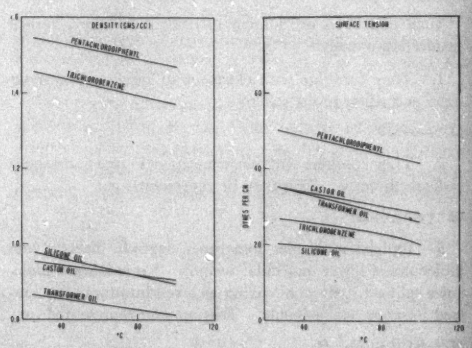


Fig. 5. Chemical structures: *A—Alicyclic hydrocarbons in transformer oil; B—Quinones; C—Castor oil; D—Silicone oil; E—Trichlorobenzene; F—Pentachlorodiphenyl.* **Fig. 6. Relationship of density to temperature of the five commercial liquids. Fig. 7. Relationship of surface tension to temperature of the five commercial dielectrics**

Table I. Gamma Ray Yielding Radioactive Elements

Substance	Half Life	Energy in Mev
Potassium 42	12 hours	1.51
Sodium 24	14.8 hours	2.30
Chromium 51	26 days	0.32
Indium 114	50 days	0.186
Cobalt 60	5.2 years	1.1, 1.3
Cesium 137	33 years	0.65
Zinc 65	250 years	1.11

Table II. Properties of Five Commercial Dielectric Liquids

	MW	Pour Point	Flash Point	Acidity
Transformer oil	330	−40	135	<0.01
Castor oil	975	−13	515	0.12
Silicone oil	300	−84	315	<0.01
Trichlorobenzene	181	17	195	0.01
Pentachlorodiphenyl	326	10	None	<0.01

Table III. Electrical Properties of Five Commercial Liquids after Irradiation

	Dose (Megareps)	1 Kc Initially	1 Kc After Irradiation	10 Kc Initially	10 Kc After Irradiation
Transformer oil	43	2.23	8.59	2.23	2.84
Castor oil	43	4.46	4.59	4.47	4.60
Silicone oil	24	2.73	2.77	2.73	2.74
Trichlorobenzene	4	4.11	4.15	3.94	3.96
Pentachlorodiphenyl	7	5.04	5.10	5.00	5.04
		Per Cent Power Factor			
Transformer oil	43	0.30	75.00	0.30	51.00
Castor oil	43	0.50	0.80	0.30	0.51
Silicone oil	24	0.30	1.21	0.30	0.60
Trichlorobenzene	4	11.40	44.21	1.60	4.61
Pentachlorodiphenyl	7	0.50	2.71	0.90	2.42
		Dielectric Loss Factor			
Transformer oil	43	0.006	6.150	0.006	1.42
Castor oil	43	0.022	0.036	0.013	0.023
Silicone oil	24	0.008	0.033	0.008	0.016
Trichlorobenzene	4	0.450	1.722	0.047	0.181
Pentachlorodiphenyl	7	0.025	0.132	0.045	0.121

Table IV. Chemical Changes Due to Irradiation

	Dose (Megareps)	Neutralization Number	N_A	G_A
Transformer oil	43	4.02	32×10^{18}	1.5
Castor oil	43	0.54	6×10^{18}	0.3
Silicone oil	24	<0.01	—	—
Trichlorobenzene	21	2.41	36×10^{18}	3.2
Pentachlorodiphenyl	7	1.07	18×10^{18}	5.0

NN = Neutralization Number = Number of milligrams of KOH required to neutralize one gram sample.
The number of milligrams of KOH reacting with 1 cubic centimeter of an unknown sample is $NN\times\rho$ where ρ is the density.
The number of KOH molecules reacting with the acid molecules in 1 cubic centimeter of unknown is called here the acid equivalent N_H and is $N_A=\frac{(6.03\times10^{23})NN\times\rho}{MW(KOH)}$

Table V. Chemical Changes in Irradiated Trichlorobenzene Containing Additives

Additive	G_A	Per Cent Change in Stability
None	3.2	—
2-tert.-butyl anthraquinone	2.7	21
tintelerapheny1	2.7	21
Ultraviolet absorber no. 14	1.7	89
Ultraviolet absorber no. 9	1.7	89
Uvinal 490	1.5	111
Uvinal 400	1.4	122

G_A = number of acid equivalents generated per cubic centimeter of liquid per 100 ev

10. The purpose in presenting these data is to show the magnitude of the changes which these values undergo and consequently the difficulty involved in interpreting changes in them due to irradiation.

IRRADIATION OF COMMERCIAL LIQUID DIELECTRICS

Samples of liquids having properties corresponding to those described were sealed in glass ampoules 100 by 15 mm and placed in the field of gamma radiation. Between 4 and 8 milliliters of liquid were irradiated for periods of as little as 5 hours and as long as 1 month corresponding to doses of 2.5 megareps to 84.1 megareps. Above the liquid, air was originally present corresponding to the usual conditions in practice.

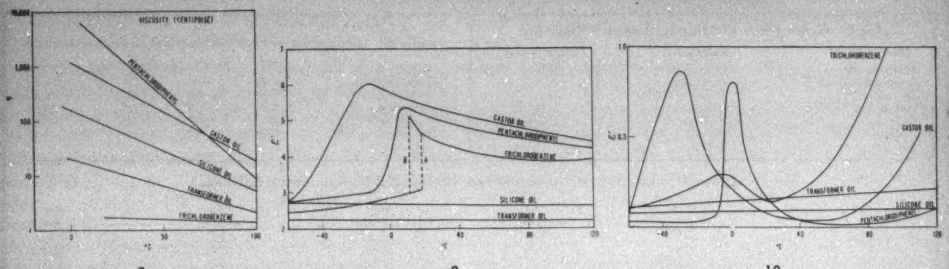
In general the only substance which changed dramatically in the time and with the doses employed was the silicone liquid. This became increasingly viscous with irradiation up to 30 megareps, whereupon it was transformed into a rubbery self-supporting gel. Further irradiation resulted in the gel becoming a fragile transparent body which crumbled into a powder on being handled. It is thought this indicated that the action of the gamma rays on this substance results in polymerization (from the increased viscosity), cross-linking (from the gel structure), and finally chain-fracture (from the powdery end-product). Unlike the other substances there was no change in color with irradiation.

Evolution of hydrogen chloride and darkening of color characterized the effect of gamma rays on trichlorobenzene and pentachlorodiphenyl, the latter becoming increasingly cloudy with time due to the formation of gas within the viscous liquid. This was easily removed either by heating or by dilution with trichlorobenzene.

Neither the transformer oil nor the castor oil exhibited any dramatic changes under the conditions employed though it is to be expected and has been shown by others that at high dosages they become gels in a way similar to silicone oil.

The electrical properties of the liquids after irradiation are listed in Table III and are seen to be characteristic of liquids very much in need of refining.

The values presented are those observed on liquids not necessarily subjected to the same amount of radiation. Thus trichlorobenzene when subjected to 20 megareps had



8 9 10

Fig. 8. Relationship of viscosity to temperature of the five commercial liquid dielectrics. Fig. 9. Dielectric constant (1 kc) vs. temperature of the five commercial dielectrics. Fig. 10. Dielectric loss factor (1 kc) vs. temperature of these dielectrics

an undeterminably high power factor at 1 and 10 kc; whilst the change in that of castor oil at 4 megareps was inappreciable. The dielectric constants of all substances rose and since the loss factors rose concomitantly, the reason for the increase is most likely the presence of ions generated by the radiation. This is substantiated by the fall in resistivity and rise in acidity of the liquids. The change in the dielectric constant of transformer oil at 1 kc is almost fourfold and suggests the need for serious study in stabilizing the important liquid. The change in trichlorobenzene, while greater per unit of dose, is in line with the well-known radiation sensitivity of the halogenated compounds. Efforts to stabilize this substance will be reported later. While the change in dielectric constant of silicone oil is slight in comparison with transformer oil, the increase in viscosity and consequent decrease in heat-transfer ability must be considered by the design engineer in using these results.

It is noteworthy that (under the conditions of test) castor oil apparently resisted change most. This intrinsic stability is thought to arise from the unsaturated nature of the ricinoleate present in the oil.

The composition of the gases evolved were not determined in this work due to the original air present and the confusion which must necessarily enter with the probable reactivity of this with the substance being irradiated. However, the increases in acid number of the liquids were determined and are given in Table IV. Because different amounts of substance were irradiated and because the samples did not always receive the same dose, it has been thought that the information might best be described in terms of a constant G_A which is defined as the number of acid groups formed in a cubic centimeter of liquid by the absorption of 100 electron volts (ev) of energy. This resembles the G value of nuclear physics, namely the number of bonds ruptured per cubic centimeter per 100 ev. It is thought that this method provides an engineer with a means of relating the time-tested controls, such as acid number commonly arising in present practice, to the value which would arise if gamma radiation affected the insulant. Hence the acid values of the oils after irradiation are given and the number of acid equivalents generated per unit volume of liquid per 100 ev calculated.

The number of acid equivalents generated is seen to be greatest for the pentachlorodiphenyl compounds and least for silicone oil. In the former the chief product of decomposition is hydrogen chloride, while in the latter it is hydrogen. Although the efficiency of the gamma rays in destroying the substances is not determinable from the data presented, in the case of trichlorobenzene an estimate can be made by considering the action to center around the rupture of the carbon-chlorine bond. The energy associated with such a rupture is 70 kilocalories per mole or 3.04 ev per bond. Hence, if the photons were totally effective 33 bonds might be expected to rupture through the action of 100 ev. The effectiveness of the photons in transforming trichlorobenzene into acids under the conditions of test is therefore 10 per cent while in the case of pentachlorodiphenyl by similar reasoning it is approximately 15 per cent. The total efficiency of the photons is higher than this because reactions other than those yielding hydrogen chloride occur. These figures are useful however in cases where control checks involve changes in acid values.

EFFECT OF ADDITIVES ON THE TRANSFORMATION OF TRICHLOROBENZENE

The decomposition of the five commercial liquids when placed in a field of intense gamma radiation may arise through the mechanism of ionized and excited molecules as well as through free and atomic radicals. If the latter be true, it would suggest that stabilization of a given liquid might be obtained by the judicious inclusion of a substance having a capacity to react with such particulates rapidly and completely, yielding as a residue a stable and unreactive free radical. Quinone derivatives have been known to exhibit such qualities; also diphenylpicrylhydrazyl. Since a number of such materials have been used successfully for 15 years to improve the life of capacitors in constant- or low-frequency fields, and are known to raise the dielectric strength of such liquids, tests were undertaken using trichlorobenzene to which 0.3 per cent of each of the substances listed in Table V were added. Since the commercial additives frequently differ in their stabilizing action due to minute traces of foreign materials and since such additives are generally specified by their proprietary names,

this practice has been followed. The four proprietary items are substituted benzophenones.

The samples were sealed in ampoules and irradiated and then tested for the amount of acid formed and for the condition of the liquid after irradiation. As can be seen from the data, the number of acid groups formed when butyl anthraquinone was present was less than without the additive. From the data presented, estimates can be made of the amount of radiation which might be expected to transform the trichlorobenzene containing an additive into a rejectable condition.

The proprietary products, all of which are free radical acceptors, decrease the tendency of the liquids to convert into acids to such an extent that they are capable of absorbing twice as much radiation before reaching the condition of the uninhibited samples. These tests suggest that engineering studies on the inhibiting qualities of the additives in dielectrics under stress in radiation fields are warranted.

CONCLUSIONS

FROM THESE TESTS, it is apparent that gamma radiation can transform dielectric liquids appreciably either by converting them into solids or by decomposing them into acids and gases. By using the factor G_A as a characteristic, it is possible to evaluate various liquids and to calculate the changes in liquids to be expected in equipment subjected to irradiation. Finally it would appear that additives are available which can increase the stability of such liquids subjected to gamma fields.

Noise Reduction in Large Rotating Machines

J. M. SHULMAN
ASSOCIATE MEMBER AIEE

Tests indicate that by proper application of sound-absorbing materials in electric machines, it is possible to obtain noise reductions of the order of 5 to 10 db. If economy is not a factor, greater reductions can be obtained, although the law of diminishing returns sets in rapidly.

USERS of large motors and generators are becoming increasingly noise-conscious. The effect of continuous loud noise on the human makeup, although not as yet a fully ascertained quantity, is agreed to be detrimental and in severe cases is thought to be unsafe. Much work has been and is being done[1-3] to obtain and correlate data which may lead to more definite standards for noise in terms of human comfort and safety. In the meantime, low noise level in electric machines has become a sought-after performance characteristic. For operation in relatively quiet places it is not uncommon for a maximum noise level to be stated in machine specifications. Moreover, these maximum noise levels in some cases are lower than those considered satisfactory only a few years ago.

Full text of conference paper CP55-134 presented at a session of the AIEE Committee on Rotating Machinery, AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955.

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The author is indebted to A. R. Gilmour of Westinghouse Electric Corporation for his contributions to the materials in this article.

Two basic approaches to the problem of noise reduction in electric machines are: (1) reducing the generated noise level; and (2) dissipating as much of the generated level as possible before it gets outside the machine. One should also consider an indirect approach of: (3) deadening the noise as much as possible after it is out of the machine. The first approach has received a great deal of attention in the design of electric machinery and will not be considered here, except to note that good design practice dictates it should come first in attempts at noice reduction. The second approach is the subject to be discussed. Internal dissipation of noise is accomplished by lining as large a portion of the interior surfaces of the machine as practicable with sound-absorbing materials. Inherently this method is applicable only to large machines. For machines of integral horsepower sizes and smaller, the third approach is often effective.

As a starting point in determining what can be done in the way of noise reduction by internally applied sound-absorbing materials, it is helpful to know what can be expected before these measures are used. Fig. 1 shows the results of 160 noise tests on motors from 150 to 2,500 hp. These machines are representative of good design practice in terms of having employed all economically feasible measures for the reduction of generated noise. The range of ordinates within the block covers different enclosures tested and speeds from 3,600 rpm down to approximately 360 rpm.

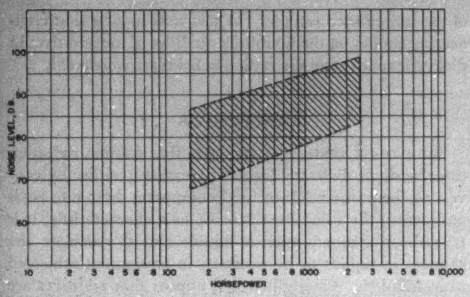

Fig. 1. Range of noise levels to be expected on large motors without special noise reduction measures (results of 160 tests)

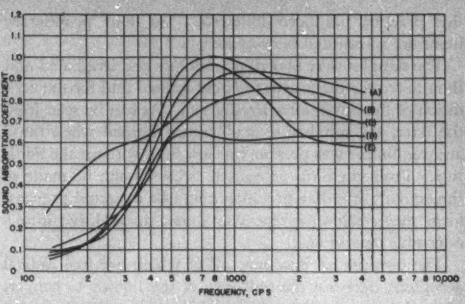

Fig. 3. Sound-absorption coefficients of some of the materials suitable for internal application on machines:

A—Fiberglas flexible duct liner, 1 inch thick; B—Acousti-Celotex perforated mineral tile, 5/8 inch thick; C—Acousti-Celotex perforated mineral tile, 1 inch thick; D—Acousti-Celotex cane fiber tile, 1/2 inch thick; E—Acousti-Celotex cane fiber tile, 3/4 inch thick. (Data courtesy Owens-Corning Fiberglas Corporation and the Celotex Corporation)

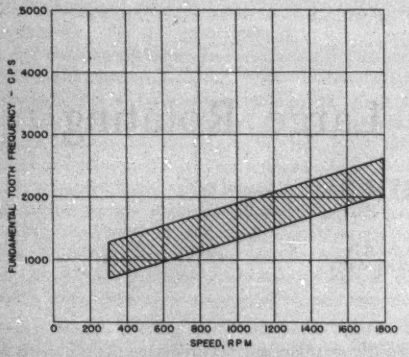

Fig. 2. Approximate range of fundamental tooth frequency noises encountered on large motors (from design data on 80 machines ranging from 150 to 2,500 hp)

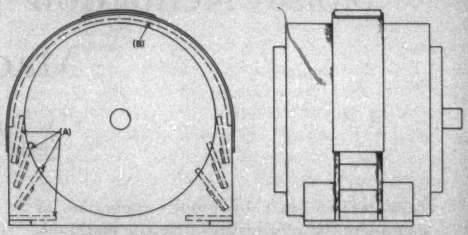

Fig. 4. Internal application of (A) perforated mineral tile, and (B) flexible duct liner to a motor frame, to reduce the noise level; both materials are 1 inch thick

Of all the frequencies composing the generated noise of electric machines, the tooth frequency components are usually the most troublesome, whether caused electrically or mechanically. The whir of air through an open machine or through ducts is usually not objectionable, but electric slot whine or the siren effect of air in slots or near rotor bars almost always has a damaging effect on persons nearby.

Fig. 2 shows approximate range of fundamental tooth frequencies for machines of 150 to 2,500 hp. Many of these are in the most troublesome region from the standpoint of ear response, the range in which noise meter readings are most heavily weighted.

To line the interior surfaces of a machine, it is convenient to use flexible material on curved surfaces. Perforated acoustic tile can be mounted on flat surfaces or surfaces with large radii. Noninflammable materials should be used in all electric machines. Fig. 3 shows the sound-absorption coefficients as a function of frequency for some of the materials suitable for this purpose. Using the data of Fig. 3, it is possible to estimate the noise reduction which can be realized at a certain frequency by applying these materials to a given area of internal machine surface from the equation

$$\text{Db} = 10 \log \left\{ \frac{A_1K_1 + A_2K_2 + \ldots + A_nK_n + [A - (A_1 + A_2 + \ldots + A_n)]K_s}{AK_s} \right\}$$

where A is the total interior machine surface, K_s is the sound-absorption coefficient of the machine surface before lining, and A_1, $A_2 \ldots A_n$ the areas of surfaces lined with materials having sound-absorption coefficients K_1, K_2, $\ldots K_n$.

A typical application in which noise of a large induction motor was reduced by the application of sound-absorbing materials internally on the frame only is illustrated by Figs. 4, 5, and 6. The interior of the frame and frame cover were lined with Fiberglas flexible duct liner, 1 inch thick, held by bolts with wide washers engaging tapped holes in the frame. Air-directing baffles at the air outlets on each side and the feet of the motor were used as mount-

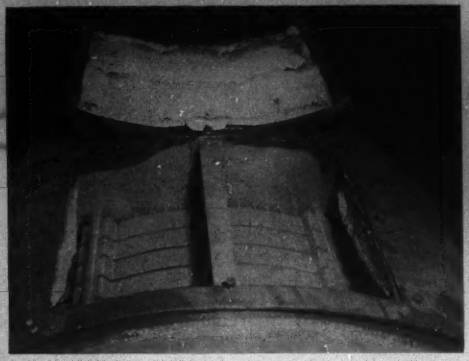

Fig. 5. Method of fastening flexible duct liner to frame and cover

Fig. 6. Method of fastening perforated mineral tile to baffles

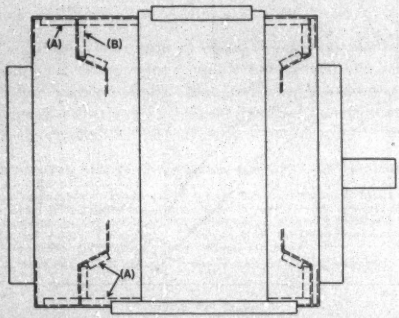

Fig. 7. Internal application of (A) 1-inch-thick flexible duct liner, and (B) 5/8-inch-thick perforated mineral tile to end cylinders and airshields of motor

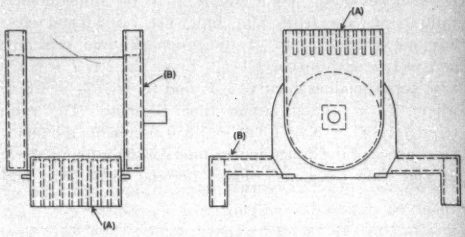

Fig. 8. Sound-absorbing boxes applied to a duct-ventilated motor—(A) baffles of 5/8-inch-thick perforated mineral tile, and (B) linings of 1-inch-thick flexible duct liner

ing plates for pieces of 1-inch-thick asbestos perforated acoustic tile. This motor before treatment had a noise level of 87 db, predominantly due to a slot windage component at approximately 2,000 cycles. With eight acoustic tile surfaces and the flexible duct liner, the noise level was reduced to 79 db.

On machines where blower noise is excessive, Fig. 7 illustrates a method by which this noise has been effectively reduced. Flexible duct liner is cut into segments and mounted on the cone portions of the airshields. Perforated acoustic tile is cut into segments and mounted on the ring portions of the airshields. The end cylinders are lined all around with flexible duct liner.

Installations where air inlets or outlets on a machine are ducted sometimes require that machine noise be kept out of the ducts. In these cases, it is practicable to make sound-absorbing boxes at the inlet and outlet ducts in addition to lining interior surfaces of the machine. An example of this is shown in Fig. 8. Here the sound-absorbing boxes were formed by placing perforated acoustic tile baffles parallel to the direction of air flow, the objective being to obtain the maximum area of sound-absorbing material possible within the limiting dimensions of the boxes.

Each individual installation of rotating machines will have its own set of factors in determining whether additional noise reduction beyond that designed into the machines is necessary or desirable. Sometimes it is possible to determine this only after the machines are installed and running. In these cases, the internal dissipation methods offer an economical means of obtaining up to 10 db or more of additional noise reduction without major constructional changes.

REFERENCES

1. The Industrial Noise Problem—A Progress Report, **D. E. Wheeler, A. Glorig.** *Magazine of Standards*, New York, N. Y., July 1954, pp. 208–10.

The Relations of Hearing Loss to Noise Exposure. Report of American Standard Association (Subcommittee *Z24-X-2*), New York, N. Y., 1953.

Sound and the Human Ear, **S. Bennon.** *Westinghouse Engineer*, Pittsburgh, Pa., March 1949, pp. 60–4.

Frequency Response From Transient-Response Data

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FREQUENCY response from experimental transient-response data is a most sought-after transformation. Basically, the transient response of a linear system is governed by the roots of its characteristic equation. This suggests that the transient response may be used to find these roots when the equation for the system is not known. If the roots so found are real, simple graphical procedures yield the corresponding frequency response. Complex roots are not considered here.

Briefly, the procedure is as follows: By inspection of the transient-response curve, Fig. 4, determine the actual times t_1, t_2, and t_3 corresponding respectively to 10-, 40-, and 80-per-cent response. For example, here the dimensionless ratio $(t_3-t_1)/(t_2-t_1) = 3.0$. Enter Fig. 1 at 3.0 and select any convenient group of dimensionless time constants such as 1, 0.520 from curve 1-T. Enter Fig. 2 at $T = 0.520$ and, corresponding to curve 1-T, find $(t_2-t_1)/T_1 = 1.890$, where T_1 = actual largest time constant. The ratio $(t_3-t_1)/1.890 = 3.50/1.890 = 1.850$ represents the factor for converting the dimensionless time constants found above to real time constants. These become then 1.850 and

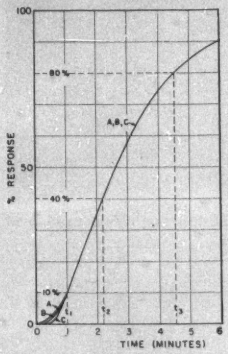
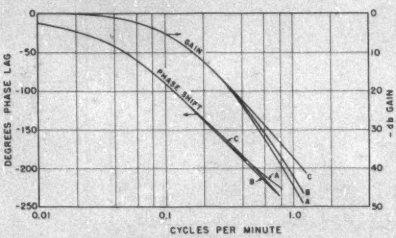
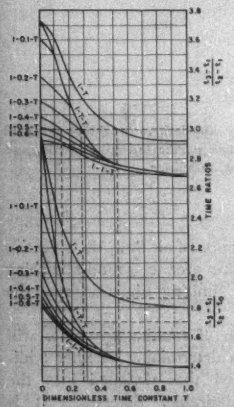
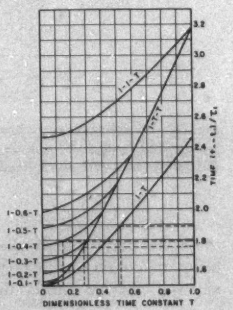


Fig. 4 (left). Transient-response curves corresponding to frequency-response curves of Fig. 5. Fig. 5 (below). Frequency-response curves corresponding to transient-response curves of Fig. 4







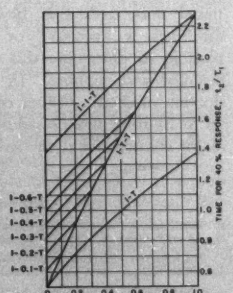


Fig. 1 (above). Normalized curves yielding time-interval ratios of the transient response corresponding to combinations of various time constants. Fig. 2 (above right). Time interval between 10- and 80-per-cent response on the transient corresponding to combinations of various time constants. Fig. 3 (right). Time for 40-per-cent transient response corresponding to combinations of various time constants

0.963 minimum. Also enter Fig. 3 at $T = 0.520$ and, corresponding to curve 1-T, find $t_2/T_1 = 1.018$. Multiplication by 1.850 yields $t_2 = 1.885$ minimum. Discrepancy between the actually observed $t_2 = 2.14$ minimum and 1.885 minimum yields the dead time $t_0 = 0.255$ minimum. The transfer function corresponding to the transient, then, is: $e^{-0.255S}/(1.850S + 1)(0.963S + 1)$. This function, by simple graphical means, then yields the frequency response corresponding to the transient. The curves labeled C in Figs. 4 and 5 correspond to the transfer function.

Other choices might have been made for the group of dimensionless time constants. The use of curve 1-T-T would have yielded the transfer function $1/(1.995S + 1)(0.549S + 1)^2$ represented by curves A in Figs. 4 and 5, while the use of curve 1-0.4-T would have produced the transfer function $e^{-0.080S}/(1.955S + 1)(0.782S + 1)(0.264S + 1)$ represented by curves B in Figs. 4 and 5. The comparatively close agreement between the three sets of curves is noteworthy.

Digest of paper 55-191, "Frequency Response From Transient-Response Data," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1955. Scheduled for publication in AIEE *Applications and Industry*, 1955.

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Analysis of a Magnetic Frequency Multiplier

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THE BEHAVIOR of Deltamax reactors having rectangular hysteresis loop for sinusoidal applied voltages is similar to a gas tube: current for a given voltage flows only for a portion of the cycle called the "conduction angle," and is practically negligible outside this range. Though the conduction angle increases with an increase of the amplitude of the applied voltage, the relationship between this angle and the voltage is quite different from that of a gas tube and is controlled by two factors, namely, the critical value of flux density at which the core saturates, and the nature of the series load. This relationship was derived for the two cases of pure resistance load and a load comprising series resistance and inductance, as shown in Fig. 1, thus:

1. The critical voltage at which firing takes place is a characteristic of the reactor, unaffected by load condition.
2. For voltages higher than the critical voltage, the presence of inductance in the load increases the conduction angle, thus increasing the sensitivity of the reactor.

The waveshape of the current for the case of resistive loading is a portion of the sinusoidal current which would flow when the reactor is substituted by a resistance equal to its winding resistance. Adding inductance may improve the waveshape but decrease the amplitude of the output. Thus a compromise between power and waveshape must be made. For a conduction angle of 60° a value of $\omega L/R=0.5$ at saturation yields an approximately sinusoidal output. Making use of this fact, a frequency multiplier operating from 60 cycle-per-second (cps) 3-phase supply and delivering an approximately sinusoidal output at a frequency of 180 cps was built. It consisted of three identical Deltamax reactors, each fed from one of the isolated phases of the supply and sharing a common inductive load. The phase voltages were fixed at equal values corresponding to a conduction angle of 60°; action between branches is negligible, and the output is the sum of the separate phases (Fig. 2).

Assuming a conduction angle of 60° and $\omega L/R = 0.5$, the output is sinusoidal and the expression for maximum power output of the tripler is of the form: $P_{max}=0.0134E^2_{60}/R_\omega$, where R_ω is the winding resistance of Deltamax reactor, and E_{60} is the rms applied voltage corresponding to a conduction angle of 60° considering a single phase which may be calculated from Fig. 1. Thus the maximum power output of any size tripler may be estimated.

Digest of paper 55-69, "Analysis and Design of a Magnetic Frequency Multiplier," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Communication and Electronics*, March 1955, pp. 99–106.

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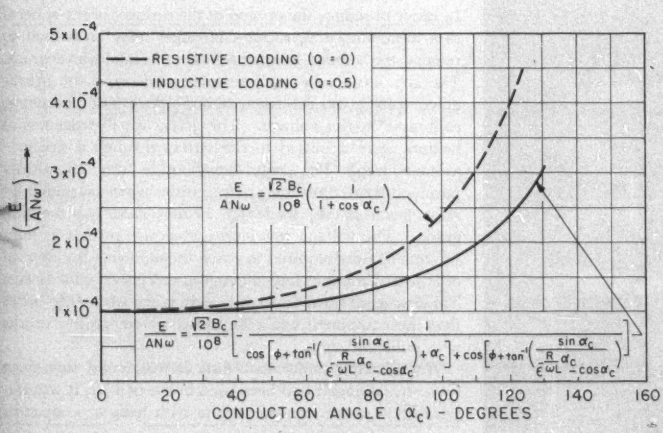

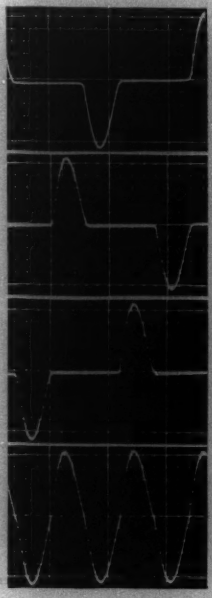

Fig. 1 (above). Relation between $E/AN\omega$ and conduction angle for reactors with Deltamax cores. *B_c—1,400 gauss; E—rms applied voltage; A—effective core area, cm²; N—number of turns; ω—angular frequency of supply.* **Fig. 2 (right). Oscillograms showing that the output of the multiplier is the sum of the outputs of three basic circuits, each connected to the load separately**

Some Electrical and Thermal Characteristics of Helium and Sulfur-Hexafluoride Mixtures

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A study of some of the electrical and thermal properties of mixtures of helium and sulfur-hexafluoride, as compared with pure gases, shows that the mixture is attractive as a cooling and insulating medium for both static and rotating machines. It has electric strength greater than that of either air or of hydrogen, and has thermal properties nearly as good as hydrogen.

HYDROGEN, H_2, is often used as a gaseous cooling medium in electric machines,[1–3] where high heat transfer and low windage power losses are desired. This gas has some disadvantages: Its electrical breakdown strength is about 65 per cent that of air over a considerable range of pressures; there is a certain amount of hazard involved because of the possibility of air mixing with the hydrogen, either inside the machine or in pockets outside; and the permeation rate of hydrogen from metal containers is greater than for other gases.[4,5]

Helium, He, has nearly as good thermal properties as hydrogen, its loss through metals is very low compared to hydrogen, but its electrical strength is very low. It is now well known that the presence of small amounts of electronegative gases tends to raise the breakdown voltage of gases.[6] However, there appears to have been no study of the possibility of developing a gaseous mixture having both high electric strength and good thermal properties. The following text summarizes the results of a study of the electrical and thermal characteristics of mixtures of helium and the electronegative gas, sulfur-hexafluoride, SF_6.

Fig. 1. Experimental apparatus

APPARATUS

ALL electrical and thermal measurements were made in a 9-inch bell jar. The base plate and internal arrangement are shown in Fig. 1. All spark breakdown voltages were for 60-cycle-per-second (cps) power and were measured for 1-inch-diameter hemispheres, which were of stainless steel and had a 1/8-inch radius of curvature at the back edges. In order to reduce the erosion of the surfaces of the spheres to a minimum, a thyratron-controlled relay* was used to remove the voltage upon the flow of breakdown current. The gap was set by a micrometer screw, and the breakdown voltage was measured by an electrostatic voltmeter, calibrated in rms voltage. The gases, air, hydrogen, and helium, were admitted to the system through a dry ice–acetone trap. The sulfur-hexafluoride was chemically pure and showed no trace of impurities when examined by mass spectrograph, while the helium used was welding grade. The voltage was increased slowly so that at least 15 seconds were required to reach breakdown. An interval of at least 1 minute elapsed between successive breakdowns. The first spark breakdown data were taken with air in order that the equipment could be tested by comparing results with published data.

While taking exploratory data it was found that once sulfur-hexafluoride had been used in the bell jar, it was impossible to obtain consistent data with helium, even after

Full text of paper 55-10, "Some Electrical and Thermal Characteristics of Helium and Sulfur-Hexafluoride Mixtures," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Communication and Electronics*, 1955.

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* Developed by S. Reynolds of General Electric Research Laboratory.

repeated flushings with pure helium. Once contaminated, the breakdown voltage obtained with helium depended markedly on the time that was permitted to elapse between breakdowns. The data presented in Fig. 2 show that there is quite a systematic dependence of breakdown voltage of helium upon the time permitted to elapse between breakdowns. Point *6*, at 1,000 minutes, represents the upper limit of breakdown voltage, and point *7*, taken 1 minute after a preceding breakdown, is approximately the lower limit. This lower limit is equal to the value obtained for helium before any sulfur-hexafluoride was used in the system. The effect was certainly caused by residual amounts of sulfur-hexafluoride in the system. The flushing alone would have reduced the gaseous proportion of sulfur-hexafluoride to an extremely small value; however, large surface areas are present upon which many layers of gaseous impurities are adsorbed. Thus no realistic estimate of the amount of sulfur-hexafluoride present could be made, but the following hypothesis appears to offer a reasonable explanation. When a breakdown takes place in a gas containing some electronegative impurities, these impurities quickly attach electrons; then as negative ions they are swept out of the active volume by the electric field. If the voltage is quickly reapplied so that insufficient time is available for new impurities to diffuse into the gap, the breakdown voltage will be that of the pure gas. As more time is permitted to elapse between breakdowns, the electronegative molecules diffuse to a sufficient density to raise the breakdown voltage. When a long time elapses, 1,000 minutes (16.6 hours) in this case, the impurities are uniformly mixed in the space, a steady state is established, and the maximum breakdown voltage is observed. It would appear that a systematic variation in spark breakdown, such as this, represents a good way to detect the presence of very small amounts of electronegative gases mixed in other gases. The procedure followed in taking the final data consisted in filling the system to nearly atmospheric pressure and pumping to 200 microns for 5 cycles. In at least 3 cycles a low-pressure glow discharge of about a 10-minute duration was established in the new gas. This procedure removed residual impurities from all surfaces to a suitable minimum value.

EXPERIMENTAL RESULTS

THE 60-cps spark breakdown voltages for air, hydrogen, helium, sulfur-hexafluoride, and mixtures of the last two are shown in Fig. 3. The volumetric proportions of the two gases are indicated as percentages. A total pressure of 74.6 cm Hg was used throughout the study. The values plotted represent the average of ten breakdowns. The rms deviations from the average value were generally from 1 to 5 per cent, being greatest for the shortest gaps. The breakdown curve for air is slightly lower than published values, probably because the electrodes were not true spheres. However, the ratio of the breakdown voltage of hydrogen to that of air is equal to the published values, namely, about 65 per cent. These curves show the marked effect of even small amounts of sulfur-hexafluoride in increasing the breakdown strength of helium. The data of Fig. 3 are replotted in Fig. 4 to bring out directly the effect of the amount of sulfur-hexafluoride mixed with the helium. As the gap length approaches the radius of the electrodes, the electric field becomes more distorted. For this reason, comparative values are given for only the shorter gap lengths when the field is more nearly uniform. The values of breakdown voltage for the helium–sulfur-hexafluoride mixtures are shown in Fig. 5 relative to that of hydrogen and of air for two gap lengths. The marked gain in electric strength of helium with small additions of sulfur-hexafluoride over both air and hydrogen is brought out quite

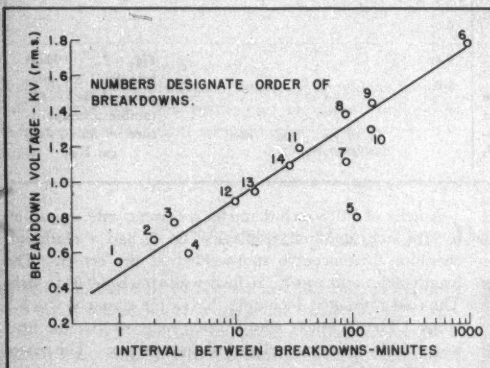
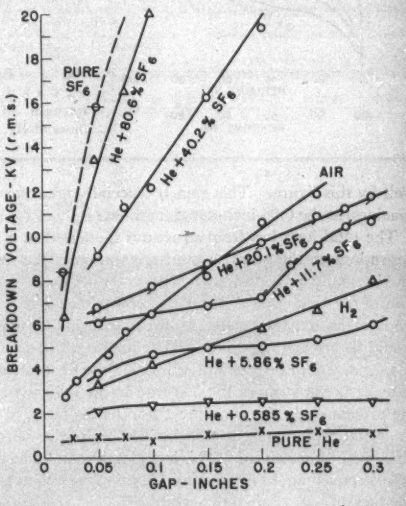


Fig. 2 (above). Effect of interval between breakdown on helium with small amount of SF_6 impurity (74.6 cm Hg). Fig. 3 (right). Spark breakdown voltages for air, He, H_2, SF_6, and mixtures of He + SF_6 between 1-inch-diameter hemispheres (74.6 cm Hg, 29.5 C, 60-cycle voltage)



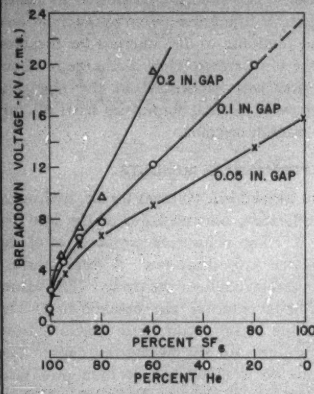


Fig. 4. Spark breakdown voltage between 1-inch-diameter hemispheres for He + SF_6 mixtures (74.6 cm Hg, 29.5 C)

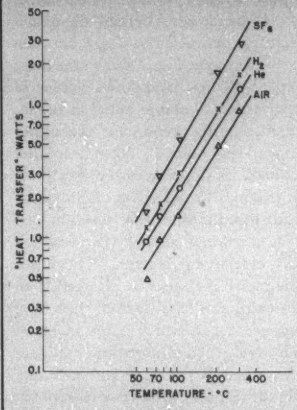


Fig. 6. "Heat transfer" by free convection and radiation for pure gases (power required to maintain temperature at center of wire helix, ambient temperature = 26 C, 74.6 cm Hg)

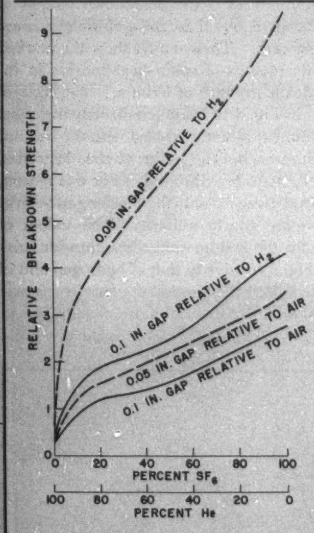

RELATIVE BREAKDOWN STRENGTH
0.05 IN. GAP - RELATIVE TO H_2
0.1 IN. GAP RELATIVE TO H_2
0.05 IN. GAP RELATIVE TO AIR
0.1 IN. GAP RELATIVE TO AIR
PERCENT SF_6
PERCENT He

Fig. 5. Relative breakdown strength of mixtures of He + SF_6

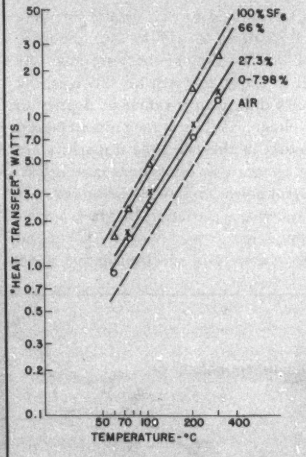


Fig. 7. "Heat transfer" for mixtures of He + SF_6 (ambient temperature = 26 C, 74.6 cm Hg)

well by this figure. This gain is especially great for small spacings, as the 0.05-inch-gap data show.

The total heat loss from structures immersed in a gas is dependent on the geometry and orientation of the surfaces and is usually quite complex. It was felt that a determination of the heat transfer for the several gases relative to air from measurements made in the same simple structure would be instructive. The relative heat transfer data, thus obtained, would be useful in estimating the heat losses from other structures where the loss rate in air is known. For the present study the term "heat transfer" is taken to mean the electric power input to a helix of resistance wire at a given wire temperature. This includes the combined action of free convection in the gas and radiation, as well as a small conduction loss through the end leads.

A helix of 0.015-inch-diameter nichrome wire wound on a 5/16-inch mandrel, visible in Fig. 1, had a platinum-rhodium thermocouple spot-welded at the center. The length of the helix was 15/16 inch, with a pitch of 0.0445 inch. The cold resistance, including that of the contacts, was 5.7 ohms. The length of wire is quite long, so that the heat loss of the leads is small relative to the total loss. The power input necessary to maintain a constant temperature of the wire at the center of the helix will be called the "heat transfer."

As shown in Fig. 1, the helix is in a large bell jar with a heavy stainless-steel plate; consequently, the heat loss is all to these surfaces. The time required to reach temperature equilibrium in the helix was so short that the surrounding surfaces were at constant temperature. The heat transfer

for a number of pure gases is shown in Fig. 6 as a function of the wire temperature, at the constant ambient temperature of 26 C. Over the range of temperature involved, the data indicate that the logarithm of heat transfer is a linear function of the logarithm of the wire temperature. The values were quite reproducible except at the lowest temperature, 60.4 C, where the measurements were somewhat erratic.

The heat-transfer characteristics of mixtures of helium and sulfur-hexafluoride are shown in Fig. 7. The relations for air and pure sulfur-hexafluoride are included for comparison. In Fig. 8 the heat transfer of the helium–sulfur-hexafluoride mixture is shown relative to air and to hydrogen as functions of the per-cent sulfur-hexafluoride. The figure shows that the heat transfer of the mixture is always greater than for air, while it is never less than 80 per cent of that for hydrogen, and is better than hydrogen for percentages of sulfur-hexafluoride greater than about 30.

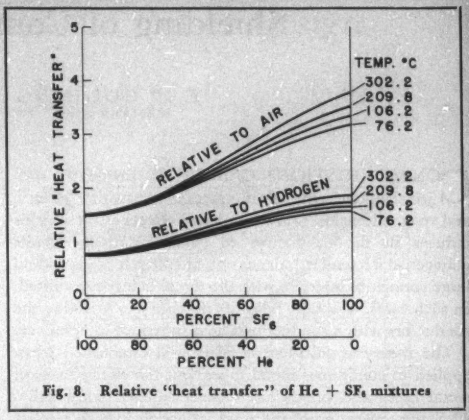


Fig. 8. Relative "heat transfer" of He + SF_6 mixtures

DISCUSSION

Some of the factors involved in a rotating device such as an alternator or a gyro are different from those involved in a static device such as a transformer or ballast reactor. In a large high-speed machine the power loss because of windage may be as much as one half the total power loss. A cooling and insulating medium should be such as to minimize this loss as much as possible, consistent with the desired electrical and thermal properties. In turbulent flow of gases the power loss increases with both viscosity and density. However, the most important factor in this windage loss is gas density. The densities of the several gases relative to air are

Gas	Density, Relative to Air
H_2	0.0695
He	0.138
Air	1.0
SF_6	5.03

Since drag is proportional to density, it is evident that for rotating machines the percentage of sulfur-hexafluoride in helium must be kept to a minimum.

In addition to the inherent safety in the use of the chemically inert gases, helium and sulfur-hexafluoride, the mixture has the advantage of being adaptable to the use of a simple halogen leak detector.[7] Permeation loss of both gases through metals is immeasurably low; however, loss of helium by permeation does take place through glass, silica, rubbers, and plastics.[4,6] The combination of an inert gas such as helium with an inert electronegative gas such as sulfur-hexafluoride to produce a gas whose electrical and thermal properties can be tailored to a particular application should have many applications.

REFERENCES

1. Standard Handbook for Electrical Engineers (book, 8th edition), edited by **A. E. Knowlton.** McGraw-Hill Book Company, New York, N. Y., 1949, section 7–138, p. 689.
2. Hydrogen as a Cooling Medium for Electrical Machinery, **E. Knowlton, C. W. Rice, E. H. Freiburghouse.** AIEE *Transactions*, volume 44, October 1925, p. 922.
3. Hydrogen—A Successor to Air, **C. J. Fechheimer.** *Electric Journal*, East Pittsburgh, Pa., vol. 26, September 1929, p. 405.
4. Diffusion of Gases Through Solids, **F. J. Norton.** *General Electric Review*, Schenectady, N. Y., September 1952, p. 28.
5. Helium Diffusion Through Glass, **F. J. Norton.** *Journal*, American Ceramic Society, Easton, Pa., vol. 36, March 1953, p. 90.
6. The Effect of Pressure on the Positive Point-to-Plane Discharge in N_2, O_2, CO_2, SO_2, SF_6, CCl_2F_2, A, He, and H_2, **H. C. Pollock, F. S. Cooper.** *Physical Review*, New York, N. Y., vol. 56, July 1939, p. 170.
7. Electronics Simulates Sense of Smell, **W. C. White, J. S. Hickey.** *Electronics*, New York, N. Y., vol. 21, March 1948, p. 100.

Vacuum Pulls Out Dents in Plane Tanks

Wing-tip tanks on an airplane are like the fenders on a car—constantly exposed to dents. Straightening such dents was a costly operation and usually meant the tank had to be cut to pieces, until the Glenn L. Martin Company developed a vacuum technique which pulls the dents out to the original smooth aerodynamic contours. The equipment is portable; it can be used at the airport, in the shop, or in final assembly. A plate, formed to the contour of the tank, is placed over the dent and sealed with a sponge rubber gasket. Connections are made to a 2-stage vacuum pump; vacuum is applied, and the dents, as well as deformed stiffeners or stringers under the dented skin, are straightened.

Shielding of Communications Cables

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H. B. SLADE
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COMMUNICATIONS CABLES are frequently subject to interference from external alternating electric and magnetic fields. The combined effects of these fields induces in the conductors of communications circuits voltages which tend to balance out, but often leave a residual large enough to interfere with the signal being transmitted. In such cases, it usually becomes necessary to surround the conductors with a conducting shield to reduce interference.

The theory of shielding is fairly well established when applied to continuous metal tubes, but the effectiveness of metal tapes and braids has to be evaluated empirically. Also, the separation of the total induction into its electric and magnetic components, and the designing of shields for greatest efficiency and economy, has not received its share of attention. This is an attempt to put the design of shields for pair and coaxial cables on a firmer technical basis.

Shielding against electric (or electrostatic) fields may be effected by enclosing the conductors in a grounded metal enclosure, such as a copper braid or overlapped metal tape. Semiconducting enclosures of carbon-impregnated paper or fabrics are also efficient electric-field shields if grounded.

Shielding against magnetic fields requires the conductors to be enclosed in magnetic material (steel tape or braid) if the frequencies involved are in the audio range. At higher frequencies copper, aluminum, and lead shields may afford a high degree of protection because of the induced eddy currents in the shield. These eddy currents set up magnetic fields which partially neutralize the fields producing them.

The efficiency of several types of shields against magnetic fields was demonstated by applying unit current to a pair of parallel conductors stretched on a 10-foot board and measuring the induction in a similar pair adjacent to it. The frequency was varied from 1 kc to 1 mc and the results are shown in Fig. 1. The solid line shows the induction for no shield over the disturbed circuit; the broken lines, the voltage induced when the disturbed pair was enclosed in the shields indicated. The circuits were short-circuited at the far end so that only magnetic induction, caused by the current in the disturbing circuit, was measured.

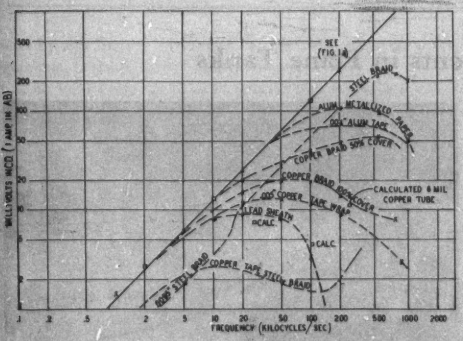

Fig. 1. Results of magnetic shielding tests

Similar tests were carried out with the circuits open-circuited at the far end to measure the electric induction. The current was zero, and the induction resulted only from the voltage applied to the wires and the capacitance couplings between them.

When two adjacent unshielded cable circuits are terminated in impedances, the disturbance which one circuit produces in the other will be caused by a combination of electric- and magnetic-field effects. In short lines, the induced voltages add at the near end of the circuit, and their magnitudes may be computed from a knowledge of the unbalance capacitances and unbalance mutual inductances between the two circuits. In uniformly twisted cable pairs, the induction is equal in each leg of the circuit and balances out, but perfect uniformity cannot be achieved.

If a cable circuit is terminated in a load equal to its characteristic impedance, the magnetic induction is inversely proportional to the impedance, and the electric induction is a direct function of the impedance. Both electric and magnetic induction is directly proportional to the frequency.

The characteristic impedance of a twisted pair increases rapidly as the frequency is reduced below 5 kc. This results in a corresponding increase in electric-field induction at low frequencies, the magnetic induction becoming unimportant.

In coaxial cables, voltage induced in the outer conductor (or shield) is transferred directly to the coaxial circuit because the outer conductor is a physical part of the circuit. For this reason, triaxial cables are sometimes used; an outer shield is applied over the inner shield and insulated from it.

Copper tubes provide excellent shielding for coaxial cables, but have the disadvantage that they are not flexible. A single copper braid (0.0063-inch wire), such as is used on r-f cables, is about equal to a 0.005-inch-thick copper tube. At 1 mc, a double braid is 25 db better than a single braid, and a triple braid is 30 db better than the double braid. To obtain efficient shielding down to the audio range, a steel braid must be incorporated. A shield which is highly efficient from 10 kc to several megacycles consists of a copper braid over a steel braid over a copper braid.

Shielding evaluation at frequencies in the 100-mc region has not yet been standardized, and awaits rationalization of test procedures. At these frequencies, the induction is almost entirely a result of electromagnetic radiation. Uniformity of disturbing field, geometrical configuration, and interpretation of results become important problems.

Digest of paper 55-198, "Shielding of Communications Cables," recommended by the AIEE Committee on Electronics and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Communication and Electronics*, 1955.

F. H. Gooding and H. B. Slade are with The Okonite Company, Passaic, N. J.

Saturating Reactor Magnetic Pulser Design

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THE magnetic pulser circuit developed by Melville[1] offers considerable design flexibility in applications requiring high-power pulses. The criteria outlined here serve to simplify the design procedure.

The basic circuit of this type of pulse switching circuit is shown in Fig. 1. Energy is transferred from one capacitor to the next through the intervening saturated inductance. The kth reactor is designed to saturate when the kth capacitor reaches peak stored energy. The reactors are designed so that the energy is switched successively more rapidly in each successive stage, thereby compressing the energy into a narrow pulse upon arrival at the load.

For the ideal lossless operation considered here, all capacitances in Fig. 1 would be equal. The magnitude of this capacitance is determined by the supply voltage and energy per pulse. When the time to charge the kth capacitor is equated to the time for the kth pulsator to go through its maximum flux swing to the saturated value, the ratio of saturated inductances is found to be

$$\frac{L_{sk}}{L_{sk-1}} = G\frac{W_m}{M_k} \tag{1}$$

where G = a constant, W_m = energy per pulse, and M_k = volume of kth reactor. Thus, for an n-stage pulser, the over-all inductance ratio is

$$\frac{L_{sn}}{2L_0} = \frac{(GW_m)^n}{\pi_{1n}M_k} \tag{2}$$

This ratio is fixed by the pulse compression ratio required. The pulse compression ratio is defined as

$$\rho = \frac{T_o/2}{t_{sn}} \tag{3}$$

where T_o = "on" time of supply voltage for each pulse, and t_{sn} = output pulse width.

In other terms

$$\rho = K\sqrt{\frac{L_0}{L_{sn}}} \tag{4}$$

where $K = 1.70$; and so the pulse compression ratio fixes both the over-all inductance and impedance ratio. For a given energy per pulse, the product of the core volumes is a constant. As a result the total volume of core material for n stages may be minimized by making all cores of equal volumes.

In addition, the number of stages has a bearing upon the total required core volume of the saturating reactors. The optimum number of stages for least total core volume is found to be

$$n = ln\left(\rho^2\frac{2}{K^2}\right) = ln\left[\frac{2L_0}{L_{sn}}\right] \tag{5}$$

Curves of this equation for three different types of input are shown in Fig. 2. From equation 5, it may be shown that the ratio of stage saturated inductances when the optimum number of stages are used is

$$\frac{L_{sk-1}}{L_{sk}} = e \tag{6}$$

in which e is the Napierian base. Or in more general terms, the pulse compression of each stage is $e^{1/2}$.

Using readily available rectangular B-H loop core material and good construction techniques, the value of G in equation 1 is about 1.0 in cgs units. When the optimum number of stages are employed, the minimum core material required is about 0.05 pound per stage per watt-second of pulse energy.

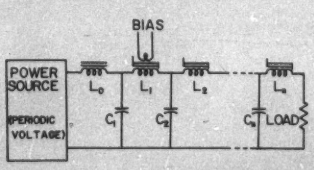

Fig. 1. Basic magnetic pulser circuit

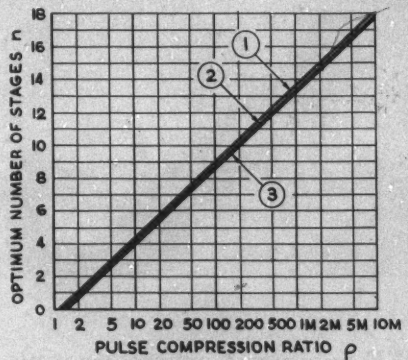

Fig. 2. Optimum number of stages. *Type of input: 1—Switched direct current, or half-cycle alternating current per pulse with L_0C_1 tuned for maximum V_{m1}; 2—Whole-cycle alternating current per pulse with L_0C_1 tuned to the alternating current; 3—Half-cycle alternating current per pulse with L_0C_1 tuned to the alternating current*

REFERENCE

1. **The Use of Saturable Reactors as Discharge Devices for Pulse Generators, W. S. Melville.** *Proceedings*, Institution of Electrical Engineers, London, England, vol. 98, pt. 3, 1951, pp. 185–207.

Digest of paper 55-179, "Economic Design of Saturating Reactor Magnetic Pulsers," recommended by the AIEE Committee on Special Communications Applications and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Communication and Electronics*, May 1955, pp. 169–71.

E. M. Williams and R. A. Mathias are with the Carnegie Institute of Technology, Pittsburgh, Pa.

This research was sponsored by the Rome Air Development Center, Rome, N. Y.

INSTITUTE ACTIVITIES

Sailboats huddle off the coast of Marblehead, Mass., near Summer General Meeting headquarters.

AIEE Summer General Meeting to Provide Diversified Program, Vacation Opportunity

THE 1955 SUMMER GENERAL MEETING to be held at the New Ocean House in Swampscott, Mass., June 27–July 1, will provide a diversified program to satisfy everyone who attends. A total of 45 technical sessions will be held and nine inspection trips of both general and technical interest have been arranged to complement the program.

Swampscott, located on Boston's north shore, is also ideally situated for a vacation. The New Ocean House, meeting headquarters, is located on the Atlantic Ocean and has a private beach, extensive grounds, and an excellent 1,000-yd golf course. One of the famous yachting centers of the world, Marblehead, Mass., is nearby. Also, Lexington, Concord, Salem, Gloucester, Plymouth, and Boston are all within easy driving distance and offer historic interest.

Technical Sessions

Almost all of the 40 technical committees of the Institute will sponsor sessions. On Monday afternoon, June 27, applications of polyethylene-insulated high-voltage power cable in chemical plants will be discussed. On Tuesday morning the Committee on Safety will present four papers on electric shock and accident prevention. At 9:30 a.m., Wednesday, the Committee on Management will sponsor two papers. One session will be devoted to the interisland radio network of the Hawaiian Telephone Company. Two sessions on Thursday will be devoted to applications and practices in the textile industry, and an examination of the following detailed program will reveal more interesting papers in the five technical fields of Institute activity.

Entertainment and Banquet

An old-fashioned barn dance is planned, for Monday evening, New England style. Appropriate costumes will add a great deal of fun to this occasion. Costumes may be simple or elaborate. Music will be furnished by Albert Haynes and his Early American Dance Orchestra, which has become well known through its association with Longfellow's Wayside Inn. There also will be old-style dancing instruction.

On Wednesday evening the President's Reception will be held in the ballroom. The banquet will take place in the main dining room. Featured speaker at the banquet will be Doctor C. G. Suits, director of research for the General Electric Company, whose subject will be, "The Science of Commonplace Things." Tickets for each of these affairs will be available at the registration desk. There will be informal dancing in the ballroom on Tuesday and Thursday evenings.

Hotel Reservations

Accommodations for members and guests have been arranged at the New Ocean House and Hotel Preston in Swampscott, the Hawthorne Hotel in Salem, the Hotel Kenmore in Boston, and a number of other smaller hotels and homes in the Swampscott area.

Requests for reservations should be sent to the New Ocean House, Swampscott, Mass., prior to June 13. The New Ocean House will assign space in a particular hotel and confirm the arrangements made. Members are asked to state order of preference in requests. However, since the headquarters hotel will accommodate less than half the anticipated attendance, requests for this hotel can be honored only to the extent of the facilities available.

Special buses will be available on a morning and evening schedule for transportation between the hotels. A nominal charge will be made for the longer trips.

The New Ocean House and Hotel Preston are available on the American Plan only—with meals served at the New Ocean House. Accommodations at other hotels are for room only, but meals may be had at the New Ocean House on a per diem or per meal basis. Rates are as follows:

New Ocean House and Hotel Preston, Swampscott	Room and Meals per day, per person
Double room with bath—twin beds	$11.50 to $13.00
Hotel Cottages (Double room with bath—twin beds)	11.25 to 11.50
Large room with bath—three beds	10.75 to 11.00
Large room with bath—four beds	10.25 to 10.50
Suite—2 double rooms with bath between	11.00 to 12.00
Corner or bay window room with bath—twin beds	13.50 to 13.75
Single room with bath (limited number available)	14.00 to 16.00

Hawthorne Hotel, Salem	Room Only per day, per room
Single room with bath	$ 6.00
Double room with bath	10.00

Smaller Hotels and Homes in Swampscott Area	Room Only per day, per room
Single room with bath	$ 4.00 to $ 5.00
Double room with bath	8.00 to 10.00

Hotel Kenmore, Boston	Room Only per day, per room
Single room with bath	$ 7.00 to $11.00
Double room with bath	11.00 to 15.00
Suite—living room, bedroom, and bath	
Single occupancy	17.00 to 19.00
Double occupancy	22.00 to 24.00

Meals may be obtained at the New Ocean House at the following rates:

Breakfast	$1.50
Luncheon	2.75
Dinner	3.50

Snacks and sandwiches may also be had at the Hotel Coffee Shop.

Inspection Trips

A program of inspection trips, of both technical and general interest, has been

arranged. Members are urged to make arrangements at the inspection trips desk immediately after registering.

Champion-International Paper Company, Lawrence, Mass. (Monday, June 27, Afternoon) Located on the Merrimac River in Lawrence. Champion-International is one of the leading manufacturers of high-quality coated papers for the fine printing industry. Visitors can watch the entire paper-making procedure from pulpwood to gleaming white sheets of paper.

Measurements Laboratory, General Electric Company, West Lynn, Mass. (Tuesday, June 28, Morning) The Measurements Laboratory is one of the most modern and best equipped. Here visitors will see the latest in test facilities for the measurement of shock, vibration and noise, environment, as well as all types of electrical and photometric measurement.

Medium Steam Turbine, Generator and Gear Department, General Electric Company, Lynn, Mass. (Tuesday, June 28, Morning) The medium steam turbine, generator and gear department manufactures power-generation and marine-propulsion equipment. Since 1903 over 21,000 kw of power-generation equipment has been manufactured and shipped by this department. Visitors may observe the manufacture and testing of turbine-generators being built for large industrial plants and for public and private utilities.

Harvard University, Massachusetts Institute of Technology (MIT), and Historic Points in Boston. (Tuesday, June 28, Afternoon) This trip will include a guided tour of specific buildings and laboratories for electrical engineering work at MIT and Harvard. Transportation for the tour will be provided in sightseeing buses.

At MIT the tour will feature a demonstration of a numerically controlled milling machine in the Servomechanisms Laboratory and the X-ray and electron generators in the High-Voltage Research Laboratory.

At Harvard, the Computation Laboratory, containing two large-scale digital computers, will be among laboratories visited.

Saugus Iron Works, Saugus, Mass. (Wednesday, June 29, Morning) This replica of a 17th-century iron works is more than just a monument to the "birthplace" of America's iron and steel industry. It is an outdoor museum where visitors can actually see the beginnings of one of the United States' greatest industries.

It is a replica of the colonial iron works as it appeared in the same location in 1650. All the essential units for making iron have been reproduced.

Charlestown Navy Yard. (Wednesday, June 29, Afternoon) This is a trip to one of the oldest naval shipyards in the United States, including a visit to the forge shop where $4^3/_4$-inch die-lock chain being used on the U.S.S. *Forrestal*, *Saratoga*, and *Ranger* is being manufactured, and to the large modern machine shop, pipe shop, and boiler shop. A large modern naval vessel in the yard will also be visited, as will the U.S. Frigate *Constitution*, built in Boston, 1794–1797, and better known as "Old Ironsides." There will be a harbor trip to the South Boston Annex, viewing the mothball fleet and one of the largest drydocks in the country.

As an alternative to the harbor trip, a visit will be made to the U.S.S. *Timmerman*, a high-speed experimental destroyer, powered with high-pressure high-temperature propulsion equipment and 1,000-volt 400-cycle service throughout.

Any alien desiring to make this trip must submit his name and country of origin to the Trip Committee, in care of A. M. Bjontegard, General Electric Company, 920 Western Avenue, Lynn, Mass. No reservations for this trip can be accepted at the meeting after Monday, June 27.

Sylvania Electric Products Inc., Woburn, Mass. (Thursday, June 30, Morning) On this trip members will visit the headquarters of the Electronics Division of Sylvania. This division manufactures a broad line of semiconductor devices, microwave components, and special-purpose tubes, such as silicon and germanium diodes, magnetrons, klystrons, flash tubes, and thyratrons.

U.S. Coast Guard Station, Salem, Mass. (Thursday, June 30, Afternoon) Located at Salem Willows in Salem Harbor, the station has an outstanding record of marine rescue operations over an area extending from Newfoundland to as far south as Bermuda.

A conducted tour of the station, including hangars and seaplane and helicopter launching ramps, will be featured. There will also be demonstrations and explanations of various equipment and techniques used in air-sea search and rescue operations.

General Radio Company, Cambridge, Mass. (Thursday, June 30, Afternoon) The General Radio Company is one of the best known manufacturers of electronic test equipment and associated high-precision apparatus. Inspection will cover all of the laboratories and methods used for small-lot production as they apply to electronic instrument manufacture.

Student Activities

Monday, June 27, has been designated as the day for special student activities. Registration at the student membership desk will take place in the morning, followed by attendance at the general session, and informal group meetings of Student members. At noon students will be guests of the General Electric Company for a catered luncheon at the Measurements Laboratory. In the afternoon there will be a technical session of special interest to students. There will also be a choice of participating in a scheduled trip or swimming. A dinner will be held in the evening for students and members at the Thomson Club, Nahant, Mass. (tickets, $1.50 for students, $3.00 for members), and a barn dance will be held at the New Ocean House.

Ladies' Program

A coffee hour will take place every morning at 9:00 a.m. On Monday at 3:00 p.m. there will be a "Get-Acquainted Tea"; Tuesday, a tour of Boston with lunch at MIT and a tour of Cambridge with the men; on Wednesday a trip to the Saugus Iron Works with the men and a tour of Marblehead, craft exhibits, antiques, and shopping at will; and Thursday, a tour of Rockport via Salem and Hammond Castle with lunch at Castle Hill, Ipswich. Ladies are

(*Continued on page 532*)

Future AIEE Meetings

Electronic Materials and Components Symposium
Penn Sherwood Hotel, Philadelphia, Pa.
June 2–3, 1955
(*Final date for submitting papers—closed*)

AIEE-APS-AIME-CIT Conference on Magnetism and Magnetic Materials
William Penn Hotel, Pittsburgh, Pa.
June 14–16, 1955
(*Final date for submitting papers—closed*)

1955 Summer General Meeting
New Ocean House, Swampscott, Mass.
June 27–July 1, 1955
(*Closing dates for TP*—closed, CP‡—closed*)

Pacific General Meeting
Butte, Mont.
August 15–19, 1955
(*Closing dates for TP—closed, CP—June 15*)

Petroleum Technical Conference
Shamrock Hotel, Houston, Tex.
September 12–14, 1955
(*Final date for submitting papers—June 13*)

AIEE-ISA Instrument Conference
Shrine Auditorium, Los Angeles, Calif.
September 12–16, 1955
(*Final date for submitting papers—June 13*)

AIEE-IRE Industrial Electronics Conference
Rackham Memorial Auditorium, Detroit, Mich.
September 28–29, 1955
(*Final date for submitting papers—June 28*)

1955 Fall General Meeting
Morrison Hotel, Chicago, Ill.
October 3–7, 1955
(*Closing dates for TP—June 6, CP—August 3*)

Aircraft Electrical Equipment Conference
Los Angeles, Calif.
October 11–13, 1955
(*Final date for submitting papers—July 11*)

Motor Application and Problems in Heating and Cooling Conference
St. Louis, Mo.
October 18–20, 1955
(*Final date for submitting papers—July 18*)

EJC-AIEE Nuclear Energy Conference
Cleveland, Ohio
December 12–16, 1955

(*Final date for submitting papers—September 12*)

*TP—Transactions papers
†DP—District papers
‡CP—Conference papers

AIEE Summer General Meeting , Swampscott, Mass., June 27-July 1

Tentative Technical Program

Monday, June 27

10:00 a.m. Annual Meeting

1. Report of the President. A. C. Monteith

2. Report of the Board of Directors. N. S. Hibshman, Secretary

3. Report of the Treasurer. W. J. Barrett

4. Report of Committee of Tellers on vote for nominees for AIEE offices

5. (*a*). Introduction of, and presentation of President's badge to M. D. Hooven

(*b*). Response by Mr. Hooven

6. Presentation of Lamme Medal to A. M. deBellis, Consolidated Edison Company of New York, Inc.

(*a*). The Establishment of the Medal. S. B. Crary, Chairman, Lamme Medal Committee

(*b*). The Career of the Medalist. J. F. Fairman, Consolidated Edison Company of New York, Inc.

(*c*). Presentation of the medal and certificate by President A. C. Monteith

(*d*). Response by Mr. deBellis

7. Any other business that may be presented

2:00 p.m. Chemical Industry

CP. Application of Polyethylene-Insulated High-Voltage Power Cable in Chemical Plants. *S. J. Rosch*, Anaconda Wire and Cable Company

CP. Factors Affecting Selection of Insulated Cable. *R. C. Graham*, Rome Cable Corporation

CP. System Neutral Grounding for Chemical Plant Power System. *H. N. Hickok, D. S. Brereton*, General Electric Company

CP55-470. Thermal Protection of Motors. G. R. Horcher, The Dow Chemical Company

55-555. Operating Experience With a Mechanical Rectifier. *J. Chamulak, J. W. Tracht*, Pennsylvania Salt Manufacturing Company; *W. C. McCullough*, I-T-E Circuit Breaker Company. Re-presented for discussion

2:00 p.m. Communication Switching Systems

55-431. Engineering Multistage Diode Logic Circuits. *B. J. Yokelson, W. Ulrich*, Bell Telephone Laboratories, Inc.

55-466. The Appraisal of Delays in Gate-Type Operation. *I. Molnar*, Automatic Electric Company

55-467. An Improved Detached-Contact Type of Schematic Circuit Drawing. *F. T. Meyer*, Bell Telephone Laboratories, Inc.

CP. Recent New Features for the No. 5 Crossbar Switching System. *J. W. Deha, R. E. Harsey*, Bell Telephone Laboratories, Inc.

55-436. Minimizing and Mapping Sequential Circuits. *W. S. Bennett*, The Johns Hopkins University

2:00 p.m. Insulated Conductors

55-466. Freezing Oil-Type Pipe Cable. *E. J. Merrell*, Phelps Dodge Copper Products Corporation

55-468. A-C Resistance of Conventional Strand Power Cables in Nonmetallic Duct and in Iron Conduit. *R. W. Burrell, M. Morris*, Consolidated Edison Company of New York, Inc.

CP55-435. Typical Applications of Nonleaded Cable on Low-Voltage A-C Network Systems. *A. Bodicky*, Union Electric Company of Missouri

2:00 p.m. System Engineering and Relays

55-469. Relay Protection for Lines Being Sleet-Melted by the Short-Circuit Method. *J. Hogan, C. G. Pohler*, Commonwealth Associates, Inc.

CP. Protective Relaying and System Planning. *J. E. Barkle, J. L. Blackburn*, Westinghouse Electric Corporation

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CP55-447. Protective Relaying as a Major Tool for System Planning. *J. R. Linders*, Cleveland Electric Illuminating Company

CP55-526. Relationship Between System Planning and Relay Protection. *E. L. Michelson*, Commonwealth Edison Company

2:00 p.m. Conference on Ethics

CP. Teaching Ethics to Engineering Students. *H. W. Bibber*, Union College

CP. What Ethics? *C. T. Chase*, Stone and Webster

CP. The Philosophy of Codes of Ethics. *L. L. Fuller*, Harvard Law School

Tuesday, June 28

9:30 a.m. Color Television

CP55-561. The Impact of Color on Television Network Facilities. *J. Thorpe*, American Telephone and Telegraph Company

55-457. Basic Problems in Film Pickup for Television Broadcasting. *E. M. Gore*, Radio Corporation of America

CP. The Continuous Film Projector and Flying Spot Scanner for Television. *R. E. Putman*, General Electric Company

CP. A Color Projection Receiver. *W. F. Bailey, R. P. Burr, R. J. Keogh*, Hazeltine Corporation

9:30 a.m. Insulated Conductors

55-443. The Limiter, Its Basic Function in Network Distribution Systems. *C. P. Xenis*, Consolidated Edison Company of New York, Inc.

55-444. Overload Classifications for Secondary Network Cables. *R. C. Graham*, Rome Cable Corporation

55-434. Time Current Damage Characteristics, Cable in Duct. *L. F. Porter*, Consolidated Edison Company of New York, Inc.

55-445. Co-ordination of Secondary Network Protection. *E. L. Leinbach*, Detroit Edison Company; *A. S. Brookes*, Public Service Electric and Gas Company

9:30 a.m. System Engineering and Power Generation

55-496. Automatic Load-Frequency Control System for Central Station Power. *G. Ehrenberg*, Minneapolis-Honeywell Regulator Company

CP55-527. A Low-Cost Automatic Computer for Economic Load Dispatching. *M. H. Welsh*, Duquesne Light Company

55-528. A Computer for Economic Scheduling and Control of Power Systems. *C. D. Morrill, J. A. Blake*, Goodyear Aircraft Corporation

CP. System Planning Practices. System Planning Subcommittee of the System Engineering Committee

9:30 a.m. Section Delegates Conference

9:30 a.m. Computing Devices

CP. Superconducting Computer Components. *D. A. Buck*, Massachusetts Institute of Technology

55-497. A Multistable Transistor Circuit. *R. A. Henle*, International Business Machines Corporation

CP. Experimental Transistor Calculator. *G. D. Bruce, J. O. Logue*, International Business Machines Corporation

55-430. A Sine Function Resistor. *K. L. Nielsen*, U. S. Naval Ordnance Plant; *E. H. Roland*, General Motors Corporation

9:30 a.m. Safety

CP55-471. Electric Shock—Its Causes and Its Prevention. *R. L. Kline, J. B. Friauf*, Department of the Navy

55-426. Protection of Personnel Against Electric Shock Hazards in Central Office Communications Equipment. *R. V. Jones*, American Telephone and Telegraph Company

CP. A Worth-while Approach to the Accident Prevention Problem. *C. T. Williamson*, Bethlehem Steel Company

CP55-525. A Discussion of Causes of Electrical Accidents and Fires and Means for Their Prevention. *E. W. McLeod*, Hydroelectric Power Commission of Ontario

2:00 p.m. Satellite Television Transmitters

CP. An Experimental Investigation of the Engineering Aspects of a UHF Television Booster Installation. *J. Epstein, W. C. Morrison, O. M. Woodward, Jr.*, Radio Corporation of America Laboratories

CP55-472. Three Low-Power UHF Television Systems. *J. B. Grund*, Sylvania Electric Products, Inc.

CP. Systems for Satellite Television Broadcasting. *T. B. Friedman*, Adler Communications Laboratories

CP. Considerations of Microwave Installations. *R. G. McLaughlin*, Raytheon Manufacturing Company

2:00 p.m. Insulated Conductors

55-473. Limiters, Their Design Characteristics and Application. *F. Heller, I. Matthysse*, Burndy Engineering Company

55-432. High-Temperature Classification of Rubber and Rubber-like Insulation of Network Cable by Oven-Heating Tests. *W. H. Couch, G. J. Crowdes*, Simplex Wire and Cable Company

55-474. A Mathematical Method for Determining Insulation Damage Curves for Network Cables. *R. H. Kolks*, Cincinnati Gas and Electric Company

55-441. Characteristic Properties of Secondary Network Cables. *S. J. Rosch*, Anaconda Wire and Cable Company

2:00 p.m. System Engineering

55-530. Forecasting the Demand for Electricity. *R. G. Hooks*, Public Service Electric and Gas Company

CP55-531. Electrical Utility Load Forecasting. *W. W. Godard*, Cleveland Electric Illuminating Company

CP55-532. Forecasting Farm Electric Power Requirements. *E. R. Brown, R. D. Partridge*, Rural Electrification Administration

55-450. The Application of Business Machines to Electrical Utility Load Forecasting. *J. G. Grantter*, Bonneville Power Administration

Official United States Navy Photograph

A $4^{3}/_{4}$ INCH-ANCHOR CHAIN for the *Forrestal* aircraft carrier is shown being manufactured at the Boston Naval Shipyard. During the Summer General Meeting members and guests may tour the Boston Naval Shipyard, including a harbor excursion for a view of the mothball fleet and dry-dock facilities.

THE SAUGUS IRON WORKS has been restored at a cost of more than $1,000,000. At the original mill, wrought iron bars were reheated and run through a set of rollers operated by two huge water wheels. This colonial iron works is scheduled for inspection during the Summer General Meeting.

CP55-533. National Income and Use of Electric Energy. *F. Felix*, International General Electric Company

2:00 p.m. Section Delegates Conference

2:00 p.m. Computing Devices

55-515. A Machine for Computing the Convolution Integral. *T. O. Ellis*, Rand Corporation; *M. R. Davis, L. L. Grandi*, University of California

55-451. A Static Magnetic Transistor Analogue Divider. *D. H. Schaefer*, Naval Research Laboratory

55-461. Four-Quadrant Multiplication With Transistors and Magnetic Cores. *R. L. Van Allen*, Naval Research Laboratory

Wednesday, June 29

9:30 a.m. Radio Communications

55-534. The Interisland Radio Network of the Hawaiian Telephone Company. *W. B. Farinon*, Hawaiian Telephone Company

55-535. Engineering Problems and Performance Record of the Hawaiian Interisland Radio Network. *W. B. Farinon, A. C. Walker*, Hawaiian Telephone Company

55-536. Equipment for Interisland Radio Circuits. *A. C. Walker, V. P. Hoover*, Hawaiian Telephone Company; *E. E. Nolan*, Lenkurt Electric Company

55-429. Impulse Noise in Narrow-Band FM Receivers. *S. P. Lapin*, Motorola, Inc.; *J. J. Swan*, General Electric Company

9:30 a.m. Transmission and Distribution

55-437. Corona Studies—In Relation to Insulation. *T. W. Lino, J. R. Nye, H. H. Brustle, J. G. Anderson*, General Electric Company

55-453. Effects of Corona on Traveling Waves. *C. F. Wagner, B. L. Lloyd*, Westinghouse Electric Corporation

55-475. Traveling-Wave Protection Problems II. *E. W. Boehne*, Massachusetts Institute of Technology

55-476. A Method for Studying Circuit Transient Recovery Voltage Characteristics of Electric Power Systems. *W. C. Kotheimer*, General Electric Company

9:30 a.m. Power Generation

55-459. An Approach to the Definition of Excitation System Response. *T. J. Bliss*, Westinghouse Electric Corporation.

CP55-462. Excitation System Response. *J. V. Baptist, S. M. Denton*, Bureau of Reclamation

CP. A Hydro Utility's Approach to Defining Excitation System Response. *P. L. Dandeno, K. R. McClymont*, Hydro-Electric Power Commission of Ontario

CP. Exciter Response. *H. W. Cory*, Allis-Chalmers Manufacturing Company

CP55-524. Field Tests of Response of Excitation System for a Synchronous Condenser. *A. N. B. Eliasen*, Sargent and Lundy

CP. Excitation System Response—Definition and Significance in Power Systems. *M. Temoshok*, General Electric Company

9:30 a.m. Management

CP. The Obligations of Engineering Management in a Large Decentralized Manufacturing Company. *C. H. Linder*, General Electric Company

CP. Challenges and Opportunities for Young Engineers in the Utility Industry. *J. W. Bennett*, Western Massachusetts Electric Company

9:30 a.m. Basic Sciences

55-428. Analysis of Nonlinear Coupled Circuits—II. *Y. H. Ku*, University of Pennsylvania

55-490. A Method of Solving Mathieu's Equation. *J. J. Smith*, General Electric Company

55-491. Magnetic Flux-Density Measurements in Rotating Machines. *B. J. Lay*, New York University; *A. Charmetz*, Ford Instrument Company

CP. Block Diagram Method of Solution of Rotating Machinery Problems. *S. Hariharan*, New South Wales University of Technology

2:00 p.m. Feedback Control Systems

CP55-548. Correlation Between Root Locus and Transient Response of Sampled-Data Control Systems. *E. I. Jury*, University of California

55-549. Optimum Switching Criteria for Higher Order Contactor Servo With Interrupted Circuits. *S. S. L. Chang*, New York University

55-550. Extension of Continuous-Data System Design Techniques to Sampled-Data Control Systems. *G. W. Johnson, C. P. Lindorff, C. G. A. Nordling*, University of Connecticut

55-551. Design Principles of Second and Higher Order Saturating Servomechanisms. *R. E. Kalman*, E. I. du Pont de Nemours and Company; *J. L. Preston*, Wright-Patterson Air Force Base

55-553. A Simple Method for Calculating the Time Response of a System to an Arbitrary Input. *G. A. Biernson*, Massachusetts Institute of Technology. Represented for discussion

2:00 p.m. Wire Communications

55-259. Aluminum Die Casting for Carrier Telephone Systems. *L. Pedersen*, Bell Telephone Laboratories, Inc.

55-559. Aluminum Conductor Steel Reinforced (ACSR) for Railroad Signal and Communications Circuits. *H. W. Adams*, Reynolds Metals Company

55-560. Frequency Shift Signaling Circuit for "45" Type Carrier Systems. *K. E. Apperi, R. S. Carruthers*, Lenkurt Electric Company

CP. A Telephone Communication System for the Green Bay and Western Railroad. *G. W. Searle, J. W. Deist*, Wisconsin Telephone Company

2:00 p.m. Transmission and Distribution

55-448. Voltage Dip and Synchronous-Condenser Swings Caused by Arc Furnace Loads. *C. Concordia*, General Electric Company

55-477. Electromagnetic Unbalance of Untransposed Transmission Lines, II. Single Lines With Horizontal Conductor Arrangement. *E. T. B. Gross*, Illinois Institute of Technology; *S. W. Nelson*, Armour Research Foundation

55-478. "Oracle" Computes Line Constants With Tensors. *R. B. Shipley, M. Hochdorf, M. Watson*, Tennessee Valley Authority

55-479. A Rational Method for the Step-by-Step Calculations in Power System Transient Stability Studies. *E. O. Norinder*, Swedish State Power Board

2:00 p.m. Electronic Reliability

CP. Standard Functional Divisions for Electronic Equipment. *R. S. Shultz, W. R. Waltz*, Vitro Corporation of America

CP. The Modular Design of Electronics: A Progress Report. *J. G. Reid, Jr., R. L. Henry, C. C. Rayburn*, ACF Electronics

CP. National Bureau of Standards Preferred Circuits Program. *J. H. Muncy*, National Bureau of Standards

CP. Prediction of Electronic Equipment Reliability Based on Design Factors. *V. Harris, M. M. Tall*, Vitro Corporation of America

CP55-498. The Eccles-Jordan Trigger Circuit With Special Attention to Transition Time. *R. Chatterjee*, Bangalore, India; *W. G. Dow*, University of Michigan

55-500. Notes on the Use of Screen-to-Plate Transconductance in Multigrid Circuit Design. *K. A. Pullen, Jr.*, Aberdeen Proving Ground. Re-presented for discussion

Thursday, June 30

9:30 a.m. Textile Industry

The morning session will be devoted to acquainting the conference with the need for recommended electrical practices for installation and use of electricity and electric devices on textile machinery. During this session the necessary background information leading to the preparation of the recommended practices will be given. Need for these recommended practices, based upon machinery builders' experience, mill operators' experience, and fire underwriters' experience will be presented.

Speakers:

V. F. Sepavich, Crompton and Knowles Loom Works

J. D. McConnell, Cone Mills Corporation

Swaffield Cowan, Factory Insurance Association

9:30 a.m. Telegraph Systems

55-501. The Ticketfax System. *A. S. Hill*, Western Union Telegraph Company

55-502. Ticketfax Electronics. *C. Jelinek, Jr.*, Western Union Telegraph Company

55-503. Ticketfax Transmitters and Recorders. *D. M. Zabriskie*, Western Union Telegraph Company

9:30 a.m. Protective Devices

55-556. Lightning Protection in a 24-kv Station—Field and Laboratory Studies. *H. R. Armstrong*, Detroit Edison Company; *R. W. Ferguson, A. R. Hileman*, Westinghouse Electric Corporation

55-557. Review of the Factors Concerned With the Use of Protective Devices Shunting Reactors. Fault Limiting Devices Subcommittee of the Protective Devices Committee

55-558. Surge Attenuation in Power Cables. *W. W. Valentine*, Potomac Electric Power Company; *J. K. Dillard, J. M. Clayton*, Westinghouse Electric Corporation

9:30 a.m. Magnetic Amplifiers

55-537. Full-Wave Reversible-Polarity Half-Cycle Response Magnetic Amplifiers. *C. B. House*, Naval Research Laboratory

55-538. Influence of Inside Diameter—Outside Diameter Ratio on Static and Dynamic Magnetic Properties of Toroidal Cores. *R. W. Roberts, R. I. Van Nice*, Westinghouse Electric Corporation

55-539. Magnetic Amplifiers in Bistable Operation. *L. A. Finzi, G. C. Feth*, Carnegie Institute of Technology

55-540. Standards for the Presentation of Data on Magnetic Amplifier Core Materials. AIEE Materials Subcommittee

CP. The Replacement of Relays and Moving Contacts with Static Control Elements—A New Concept in Industrial Control. *R. A. Ramey*, Westinghouse Electric Corporation

9:30 a.m. Basic Sciences

55-440. The Dielectric Behavior of Some Fluorogases and Their Mixtures With Nitrogen. *G. Camilli, T. W. Liao, R. E. Plump*, General Electric Company. Re-presented for discussion

55-493. Electric Breakdown of Perfluorocarbon Vapors and Their Mixtures With Nitrogen. *L. J. Berberich, C. N. Works, E. W. Lindsay*, Westinghouse Electric Corporation. Re-presented for discussion

55-494. Heat-Resistant Polyester Magnet Wire. *W. F. Gilliam, E. M. Boldebuck, J. R. Elliott*, General Electric Company. Re-presented for discussion

55-495. Heat-Resistant Insulation Systems for Motors. *C. J. Herman, K. N. Mathes*, General Electric Company. Re-presented for discussion

CP55-562. Electrical Insulation Progress. *P. L. Alger, K. N. Mathes*, General Electric Company

2:00 p.m. Textile Industry

The afternoon session will present in detail the recommended electrical practices for installation and use of electricity and electric devices on textile machinery. This program will be in the form of a panel presentation wherein each member will present a particular section of the recommended practice based upon his intimate knowledge of the subject and reasons for the recommendations.

Panel members are:

F. D. Snyder, Westinghouse Electric Corporation

R. R. Prechter, General Electric Company

M. R. Brice, Cutler Hammer Company

R. H. Clark, Warner and Swasey Company

Swaffield Cowan, Factory Insurance Association

V. F. Sepavich, Crompton and Knowles Loom Works

2:00 p.m. Rotating Machinery

55-504. D-C High-Potential Testing of Large Generators. *H. H. Lang, W. D. Houser*, Westinghouse Electric Corporation

CP. Thermal Evaluation of Enameled Wire. *J. F. Dexter*, Dow Corning Corporation

CP. Thermal Endurance Studies of High-Voltage Insulation Systems for Large Generators. *G. L. Moses*, Westinghouse Electric Corporation

CP. Guiding Principles in the Thermal Evaluation of Insulating Materials. *L. J. Berberich, T. W. Dakin*, Westinghouse Electric Corporation

2:00 p.m. Land Transportation

CP. Transit Modernization and Rapid Transit Development in Cleveland. *M. W. Rew*, Cleveland Transit System; *G. M. Woods*, Westinghouse Electric Corporation

55-563. Cleveland Transit System Gets New Rapid Transit Cars. *C. A. Koch*, Cleveland Transit System; *T. H. Murphy*, Westinghouse Electric Corporation

CP55-564. Progress in Design for Long Life of Control for Large Rapid Transit Cars. *I. W. Lichtenfels*, General Electric Company

55-565. Modernizing Service Controls on Rapid Transit. *George Krambles*, Chicago Transit Authority

CP. Co-ordination of the Automobile With Public Transportation and a Paramount Urban Area Wide Need. *E. E. Kearns*, General Electric Company

2:00 p.m. Magnetic Amplifiers

55-542. Decicycle Magnetic-Amplifier Systems for Servo Applications. *L. J. Johnson*, Hufford Machine Works; *S. E. Rauch*, University of California

55-463. Operational Magnetic Amplifier With A-F Transistor Power Supply. *R. O. Decker, F. Gourash*, Westinghouse Electric Corporation

55-543. Phase-Locking of Switching-Transistor Converters for Polyphase Power Supplies. *A. G. Milnes*, Carnegie Institute of Technology

55-465. High-Frequency Operation of Self-Saturating Magnetic Amplifiers. *H. W. Collins*, Westinghouse Electric Corporation

CP. Magnetic Logic Circuits for Use in Industrial Control Systems. *W. G. Evans, W. G. Hall*, and *R. I. Van Nice*, Westinghouse Electric Corporation

2:00 p.m. Industrial Power Systems and Switchgear

55-442. Short-Circuit Currents in Low-Voltage Systems. Joint Sections Committee on Air Circuit Breakers of National Electrical Manufacturers Association

55-427. Relay Response to Motor Residual Voltage During Automatic Transfers. *A. R. Kelly*, Standard Oil Development Company

A SECTION OF THE TURBINE-GEAR DIVISION of the General Electric Works, Lynn, Mass., is shown. Summer Meeting visitors may observe the heavy machinery work and assembling and testing of turbines and generators at General Electric's "River Works."

CP55-541. Problems Encountered in Automatic Transfer of Large Induction Motors in Industrial Applications. *R. O. Bigelow, C. Auty*, New England Power Service Company

CP. Economic Studies Applied to Industrial Power Systems. *H. B. Backenstoss*, Jackson and Moreland Engineers

55-508. Testing of D-C Interrupters on A-C Test Circuits. *E. W. Boehne*, Massachusetts Institute of Technology; *K. Chen*, Westinghouse Electric Corporation

2:00 p.m. Instruments and Measurements

CP55-482. A Liquid Scintillation Detector. *J. H. Knapton*, Tracerlab, Inc.

55-483. The Design of a New 2-Element Single-Disk Polyphase Meter. *W. J. Schmidt*, Westinghouse Electric Corporation

55-484. A New Line of Direct-Acting Recording Instruments. *L. J. Lunas, J. C. Nycz*, Westinghouse Electric Corporation

55-485. A Transducer-Type Frequency Meter. *U. L. Smith*, Westinghouse Electric Corporation

2:00 p.m. Transmission and Distribution

CP55-480. Probable Service Life of Creosoted Pine Poles in New England. *C. A. Booker*, New England Power Service Company

CP55-554. The Increasing Importance of Pole-Line Inspection. *J. A. Rawls*, Virginia Electric and Power Company; *M. S. Hudson*, Consulting Chemist

CP. Use of High-Strength Steel in Transmission Towers. *H. M. Walton*, U. S. Steel Corporation

THE PULPWOOD YARD at Champion-International Company, Lawrence, Mass., is shown above. Visitors will see the entire paper-making procedure.

Friday, July 1

9:30 a.m. Rotating Machinery

CP55-505. Design of High-Precision Synchros and Resolvers. *R. A. Heartz*, Minneapolis-Honeywell Regulator Company; *R. M. Saunders*, University of California

CP55-506. Optimum Design of Induction Torque-Motors and Servomotors. *G. Weiss*, The W. L. Maxson Corporation

55-507. Current Loci of Salient-Pole Synchronous Motors—An Extension of Blondel Theory. *J. F. H. Douglas*, Marquette University

9:30 a.m. Carrier Current and Microwave

55-458. A Study of Carrier Frequency Noise of Power Lines Part IV, Conclusion of Field Measurements. *J. D. Moynihan*, Sprague Electric Company, *B. J. Sparlin*, Westinghouse Electric Corporation

55-516. Microwave Systems Parameters for Reliable Communications. *A. Alvira, I. T. Corbell*, General Electric Company

55-517. Quadriphase—A New Approach to Time Division Multiplexing. *W. E. Evans, R. F. Lowe*, General Electric Company

CP55-566. Application of Passive Repeaters to Microwave Systems. *R. H. Davis, L. G. Walker*, Motorola Inc.

9:30 a.m. Switchgear

55-509. A New 500-Megavolt-Ampere Air Magnetic Circuit Breaker of Simplified Design. *M. J. Reilly, D. E. Weston*, Allis-Chalmers Manufacturing Company

55-460. Flux Measurements in Magnetic Air Circuit Breaker Interrupters. *W. A. Carter*, I-T-E Circuit Breaker Company

55-510. A Power Class Recloser for Higher Speed Clearing of Distribution Circuits. *E. J. Field, D. L. Leatherberry*, I-T-E Circuit Breaker Company

CP. New Distribution-Class Oil Circuit Breakers. *E. J. Casey, T. R. Coggeshall, R. H. Miller*

9:30 a.m. Theory of Rectifiers

CP. Current–Voltage Characteristics of Power Rectifiers. *J. S. Saby*, General Electric Company

CP. Surface States and Channels on Germanium. *R. H. Kingston*, Massachusetts Institute of Technology

CP. Design Specification for Silicon Power Rectifiers. *D. H. Nevon*, Transitron Electronic Corporation

CP. Mechanisms of Breakdown in Rectifiers. *K. G. McKay*, Bell Telephone Laboratories, Inc.

9:30 a.m. Instruments and Measurements

55-438. The Movable-Core Transformer as a Pickup for Industrial Telemetering Systems. *A. J. Hornfeck, L. M. Wermelskirchen*, Bailey Meter Company

55-486. A Precision Torque Balance for the Measurement of Small Torques. *R. Matthys*, Minneapolis-Honeywell Regulator Company

CP55-487. Automatic Testing and Selection of Magnetic Toroids. *R. B. Einfeldt, R. P. Fischer*, Remington Rand; *A. D. Glick*, Minneapolis-Honeywell Regulator Company

CP55-488. A New High-Speed Telemeter Transmitter for D-C Measurements. *R. M. Stuart*, General Electric Company

9:30 a.m. Transformers

55-449. Functional Life Tests of Insulation Systems for Dry-Type Transformers. *P. Narbut*, Westinghouse Electric Corporation

55-435. Proposed Test Code for Functional Temperature Endurance Tests of Ventilated Dry-Type Power and Distribution Transformers. Working Group on Life of Materials

55-452. Functional Life Evaluation of Group 2 Dry-Type Power Transformers. *H. G. Zambell*, Allis-Chalmers Manufacturing Company

55-520. Functional Life-Expectancy Tests for Liquid-Filled Distribution Transformers. *A. M. Lackie*, Westinghouse Electric Corporation. Re-presented for discussion

CP. A Study of Models for Use in Evaluating Dry-Type Transformer Insulating Systems. *I. R. Walters* and *A. L. Schneider*, General Electric Company

9:30 a.m. Magnetic Amplifiers

55-544. The Application of Perpendicularly Superposed Magnetic Fields. *R. A. Hearts, H. Buitleman, Jr.*, Minneapolis-Honeywell Regulator Company

55-545. Oscillographic Techniques for the Evaluation of Magnetic-Amplifier Response. *D. L. Critchlow*, Carnegie Institute of Technology

55-546. Formulation of Magnetic-Amplifier Circuit Equations. *D. H. Schaefer*, Naval Research Laboratories

55-71. Voltage Gain of a Resonant Dielectric Amplifier. *E. A. Sack*, Westinghouse Electric Corporation; *G. W. Penney*, Carnegie Institute of Technology. Re-presented for discussion

CP. Design Methods for Magnetic Switching Element Control Systems. *R. I. Van Nice, W. G. Hall, W. G. Evans*, Westinghouse Electric Corporation

2:00 p.m. Transformers

55-521. Control of Electrostatic Voltage Distribution in Power Transformer Design. *S. Benson, R. J. Cossaart*, Westinghouse Electric Corporation

CP55-439. A New Method for Analogue Studies of Transformers. *O. I. Elgerd*, Washington University

CP55-522. Sources of High Power Factor in Dry-Type Transformers. *G. A. Monito, L. B. Rademacher*, Westinghouse Electric Corporation

55-523. The Forced Oil-Cooled Rotary-Welding Transformer. *W. E. Shenk*, The McKay Machine Company

2:00 p.m. Switchgear

55-511. A Hydraulic Manual Power Closing Mechanism for Power Circuit Breakers. *E. R. Perry, N. W. Morelli*, Allis-Chalmers Manufacturing Company

CP55-512. Electromagnetic Forces as Applied to Circuit-Breaker Contact Design. *T. G. Bank*, Allis-Chalmers Manufacturing Company

CP55-513. New Low-Voltage Air Circuit Breaker of 25,000-Ampere Interrupting Capacity, 600 Volts. *J. W. Timmerman, O. J. Albani*, Allis-Chalmers Manufacturing Company

55-514. The Calculation of the Complete Time–Current Characteristics of Cartridge Fuses With Single Wire Element. *A. E. Guile*, Queen Mary College

2:00 p.m. Metallic Rectifiers

55-518. Selenium Rectifiers for High-Temperature Operation. *G. O. Isaacson*, Fansteel Metallurgical Corporation

CP55-519. High-Temperature Operation of Rectifiers. *H. W. Henkels*, Westinghouse Electric Corporation

Panel Discussion: Dr. S. J. Angello, Westinghouse Electric Corporation, moderator

2:00 p.m. Instruments and Measurements

55-236. Report of Dielectric Tests on a Large Hydrogenerator. *C. A. Duke*, Tennessee Valley Authority; *C. W. Ross*, James G. Biddle Company; *J. S. Johnson*, Westinghouse Electric Corporation

Official United States Navy Photograph

Courtesy General Radio Company

THE U.S.S. TIMMERMAN (left) will be visited at Boston Naval Shipyard among inspection trips planned for the Summer General Meeting. AN EMPLOYEE of the General Radio Company, Cambridge, Mass., is shown working on Variac transformers. The General Radio Company is also on the list of inspection trips scheduled for the Summer General Meeting. This will include inspection of all the laboratories and methods used for small-lot production as they apply to electronic instrument manufacture.

55-489. Measuring and Recording Atmospheric Electrostatic Potential. *J. S. Carroll*, Stanford University; *S. B. Hammond*, University of Utah; *E. H. Stewart*, Weslx Electric Heater Company

CP55-464. New Circuits for Recurrent Surge Oscillography. *D. D. Davis*, General Electric Company

55-547. An Angular Position A-C EMF Transducer and Its Application to Null-Type Records. *E. C. Guptill, C. W. McCarty*, General Electric Company

55-456. The Recognition of Possible Measurement Errors in D-C Dielectric Testing in the Field. *C. W. Ross, E. B. Curdts*, James G. Biddle Company. Re-presented for discussion

2:00 p.m. Transmission and Distribution

55-481. Economics of Higher Primary and Secondary Voltages for Commercial Areas. *R. F. Lawrence, D. N. Rapp*, Westinghouse Electric Corporation

CP. Analysis of Low-Voltage Capacitors in Series With Distribution Transformers. *G. G. Auer, R. G. Livingston, R. J. Hopkins, N. M. Neagle*, General Electric Company

CP. Application of Low-Voltage Series Capacitors With Distribution Transformers. *R. F. Lawrence, L. W. Manning*, Westinghouse Electric Corporation

(*Continued from page 527*)

urged to register early because some of the women's activities are limited to a specific number.

Social Hour

A social hour is planned for Sunday afternoon, June 26, for the early arrivals—members and guests.

Registration

Members and nonmembers should register in advance by filling in advance registration cards sent with Summer General Meeting announcements. In order to help make the meeting self-supporting, a registration fee of $3.00 will be required for members and $5.00 for nonmembers. Student members and the immediate families of members will not be required to pay any fee.

General Information

General information may be obtained at the registration desk. A table for mail and memoranda will be maintained as well as a special bulletin board for the posting of messages and notices. The schedule of inspection trips and entertainment features will also be displayed.

Committee Members

Members of the AIEE Summer General Meeting are: M. A. Princi, chairman; C. W. Maloney, vice-chairman; J. R. Macintyre, secretary; R. G. Slaver, treasurer; A. M. Bjontegard, inspection trips; J. A. Cook, finance; R. E. Franck, hotels; G. E. Wall, sports; S. M. Osthagen, publicity; N. Stadtfeld, Jr., meetings and papers; L. F. Cleveland, students' activities; J. R. Cornell, Jr., transportation; E. A. Harty, registration; J. F. Archibald, hospitality; E. K. Rohr, entertainment and banquet. Mrs. M. A. Princi, is responsible for ladies' entertainment.

AIEE Board of Directors Holds Special and Regular Meetings in St. Petersburg, Fla.

THE BOARD OF DIRECTORS held a special meeting on April 13 in St. Petersburg, Fla., to consider the report of the Committee of Five Presidents, representing AIEE, American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the American Institute of Chemical Engineers, concerning a location for the Engineering Societies Building. (Also see *Electrical Engineering*, June 1954, p. 564.) The majority report included an analysis of the available data received up to February 1, 1955, and based on that analysis made an unqualified recommendation for the Schenley Park site in Pittsburgh, Pa. The Board of Directors voted to accept and approve the majority report of the five presidents dated April 4, 1955, as presented and recommended similar action to the other four societies.

The regular spring meeting of the AIEE Board of Directors was held in St. Petersburg, April 14, 1955. The following actions of general interest were taken.

Admissions and Transfers

Approval of recommendations from the Board of Examiners added the following numbers to the membership grades indicated: 106 Members, 1,171 Associate Members, 78 Affiliates, 470 Student members.

The Board of Examiners submitted ten proposals for transfer to the grade of Fellow with a favorable recommendation and a recommended citation in each case. The Board of Directors voted to invite the ten following Members to be transferred to the grade of Fellow:

Guy Bristow Ballard, Vice-President (Scientific) and Director of Radio and Electrical Engineering Division, National Research Council, Sussex Street, Ottawa, Ont., Canada.

Roy Leo Brown, Manager, Instrument and Regulator Division, Westinghouse Electric Corporation, 469 Sharpsville Avenue, Sharon, Pa.

Thomas Henry Granfield, Assistant Vice-President (Engineering), Northwestern Bell Telephone Company, 118 South 19 Street, Omaha 2, Nebr.

John Terrill Hawley, Chief Electrical Engineer, Sanitary District of Chicago, 910 South Michigan Avenue, Chicago 5, Ill.

Walter Curtis Johnson, Chairman, Department of Electrical Engineering, Princeton University, Princeton, N. J.

Raymond Dewey Maxson, Senior Vice-President, Commonwealth Edison Company, 72 West Adams Street, Chicago 90, Ill.

Clarence Walter Minard, Assistant General Manager, Omaha Public Power District, Electric Building, Omaha 2, Nebr.

Arthur Reynolds Nelson, General Superintendent of Distribution, Electrical Department, Public Service Electric and Gas Company, 80 Park Place, Newark 1, N. J.

William Frank Uhl, President, Charles T. Main, Inc., 80 Federal St., Boston 10, Mass.

William Frederick Wetmore, Director, Planning and Project Engineering Department, The Detroit Edison Company, 2000 Second Avenue, Detroit 26, Mich.

Finances

A record budget was approved to become effective May 1, 1955. Income and expenditures are balanced, with a small appropriation to reserves, at $1,446,050.00. The budget and fiscal years of the Institute will coincide in the future. By June 1956, it will be possible to compare directly the annual auditors' report with the budget.

Organization and Procedures

President Monteith reported that management consultants are making progress with their study of Section meetings and publications and are hoping to have a report ready for the next meeting to be held in June during the Summer General Meeting. The corollary sample poll of membership opinion is being delayed by the overwhelming response to the request for suggested questions to be asked of the membership sample. There is so much interest on the part of officers and committees in membership opinion on various subjects that it appears an extensive questionnaire to the membership as a whole will be necessary early next year.

By formal resolution the Board requested all parties presenting business to it to do so in accordance with the following:

RESOLVED that the Board of Directors of AIEE desires motions, resolutions, or recommendations be first presented in writing to the Secretary twenty (20) days in advance of the meeting for mailing to the members of the Board with the agenda . . . and setting forth clearly the following information:

(1) The name of the committee, board, officer, or member presenting the motion or resolution and recommending its adoption by the Board of Directors.

(2) The purposes to be achieved by the action and the reasons for the desirability of these purposes.

(3) A citation of previous actions to be rescinded, amended, or supplemented by the proposed action.

(4) An estimate of the annual cost to the Institute of implementing the recommendation, if approved by the Board of Directors.

(5) A statement of the date on which the action is to become effective and an outline of the intended method of its implementation.

As prescribed by the Constitution, a Committee of Tellers, as follows, was selected to canvass the 1955 election and constitutional ballots: Henry A. Schumacher (chairman), Donald C. Aker, Warren H. Bliss, Nicholas Davis, Charles Dorsa, E. J. Doyle, Jay Fain, Thomas E. Kinlin, Leo C. Murphy, D. E. Winslow, Jr.

Amendments to the Constitution and Bylaws

A constitutional amendment was approved, for submission to the membership, clarifying the voting and office-holding privileges of Affiliates: ". . . their right to vote shall be limited to voting in Section elections and on Section matters, and their right to hold office shall be limited to those Section offices that do not require the office holder to participate in Institute General and District meetings as Section delegates or representatives." The foregoing change in Article II, Sec. 3, of the Constitution, together with other related changes approved for the Constitution and Bylaws, means that delegates to the June conference, and representatives to District Executive Committee meetings, and other similar deliberative bodies must be corporate members of the Institute (Fellows Members, Associate Members, and Honorary Members). This action, although not effective until voted upon in June 1956, may be considered as the Board's interpretation of the present Constitution and Bylaws, which are ambiguous on this point.

Budget Year Changes. As reported, the Bylaws were amended to make the Institute's budget year correspond to the fiscal year: May 1 to April 30.

District 2 Divided. The Board approved Bylaw changes and other actions recommended by the Executive Committee of District 2 to creat a new District 11. This is to be known as the "East Central District." It will consist of all the Ohio and West Virginia territory of District 2, except for those Ohio and West Virginia counties now assigned to Sections in Pennsylvania, Maryland, and the District of Columbia. J. C. Strasbourger of Cleveland, Ohio, was elected Vice-President of the new District, to serve for the administrative year 1955–1956.

Affiliate Branches. On recommendation of the Committee on Student Branches, the Board approved the establishment of Affiliate Student Branches at 4-year engineering colleges lacking accreditation from Engineers' Council for Professional Development. These Branches will operate essentially like present Branches, except Affiliate Student members will be eligible, upon graduation, for admission to the Institute as Affiliates.

Graduate Student Dues Reduced. On recommendation of the Committee on Student Branches, the Board acted to set the dues for all graduate Students enrolled, for at least a half schedule of graduate study, in accredited institutions, at $5.00 per year, without entrance fee.

Student Members to Associate Members. The Board provided for procedural change in previously amended Bylaws to enable acceptance of applications for Associate membership from Student members subsequent to graduation—if filed at any time prior to the expiration of Student membership (May 1, after graduation).

Future Meetings. Approval was given for a Summer General Meeting to be held in June 1958 at Buffalo, N.Y., and at Atlantic City in 1960.

New Student Branches. A Student Branch was approved for Youngstown College, Youngstown, Ohio (District 2). Affiliate Branches were approved for: Lamar State College, Beaumont, Tex.; Texas College of Agriculture and Industry, Kingsville, Tex.; University of Houston, Houston, Tex.; Tennessee Polytechnic Institute, Cookeville, Tenn.

A New Section. The Board approved, on recommendation of the Sections Committee, the establishment of a Johnstown, Pa., Section. This has been formed from eight counties previously part of the Pittsburgh Section. Most of the members of the new Section have been functioning as the Johnstown Subsection of the Pittsburgh Section.

Attendance

Present at the meeting were: *President* A. C. Monteith; *Past President* Elgin B. Robertson; *Vice-Presidents* C. P. Almon, Jr., A. S. Anderson, G. J. Crowdes, Walter B. Morton, J. P. Neubauer, S. M. Sharp, C. M. Summers, G. C. Tenney; *Directors* F. R. Benedict, Donald I. Cone, R. F. Danner, D. D. Ewing, J. H. Foote, L. F. Hickernell, R. E. Kistler, E. S. Lammers, T. M. Linville, A. C. Muir, C. S. Purnell, E. W. Seeger; *Treasurer* Walter J. Barrett; *Secretary* N. S. Hibshman.

476 Attend Technical, Social Activities At Southern District Meeting in Florida

THE AIEE SOUTHERN DISTRICT Meeting was held in St. Petersburg, Fla., April 13–15, 1955, with headquarters at the Soreno Hotel. There were 20 technical sessions besides the general session on the first day of the meeting and a series of meetings for the Student members, who were present from 18 colleges in the Fourth District. The attendance was 476 members and guests.

Social activities for members and guests included a hospitality hour, two general luncheons, a cocktail party and dinner dance, and a variety of sightseeing trips to nearby points of interest.

General Session

Chairman of the meeting I. L. Garcia opened the general session on the first day of the meeting and introduced S. G. Johnson, mayor of St. Petersburg, who welcomed members to the "Sunshine City." Before introducing C. P. Almon, Jr., Vice-President of District 4, Mr. Garcia discussed the student meetings and how the local Section had helped finance students' trips to this meeting. Mr. Almon reported on the activities of District 4 and spoke briefly on how the elevation of the engineering profession hinges on Institute members and their individual and collective activities. He in turn presented AIEE President A. C. Monteith, whose talk, "Let's Take Time to Do More Planning Ahead," is published on pp. 457–8.

W. J. Clapp, president of the Florida Power Corporation, introduced Dr. J. O. Edmunds, president of Stetson University, who spoke on "The Human Side of Business." He pointed out that a great many companies interested in the welfare of the engineering profession are assisting colleges financially,

MEETING HIGHLIGHTS

April 13-15, 1955
Southern District Meeting

TOP PICTURE: I. L. Garcia (standing) introduces C. P. Almon (center), Vice-President of District 4, at the General Session. AIEE President A. C. Monteith is sitting to the right of Mr. Almon. Bottom left: Members register, pick up programs and tickets in the lobby of the Soreno Hotel. Bottom right: This is a sample of the crowds attending technical sessions during April 13, 14, 15.

for they have realized that their existence depends upon the future generations of engineers.

One of the important things that all engineers should bear in mind is that they have to get along with people—that they must follow the Golden Rule. Dr. Edmunds stressed the fact that if more nations followed the Rule, not as much money would have to be allocated to our defense and more could be spent on benefits for citizens.

Technical Sessions

In the 20 technical sessions, which occupied the meeting until Friday noon, there were presented 75 technical and District papers. These covered a wide range of subjects: public relations, magnetic amplifiers, semiconductors, atomic energy, radio and television, and various phases of the power industry, such as transmission lines, cathodic protection, poles, aluminum conductors, etc. A special session was devoted to electrical problems of the paper and pulp industry and another to citrus processing and container manufacturing, subjects of interest to engineers of the South. Three District papers were given covering electrical aspects of the phosphate mining industry.

One of the more interesting papers given at the public relations session was by T. M. Ware, International Minerals and Chemical Corporation, "Human Engineering—A New Frontier." According to Mr. Ware, all a man's senses are needed in running today's machines and so machine designers must make it as easy as possible for the man to operate the machine correctly and efficiently. More and more the modern plant uses the man and it has been found that automation upgrades the individual.

Frank Laver, Peninsular Telephone Company, in his talk on the social aspects of business, said that management should give employees the facts about how any particular business is run, how it functions, what its aims are, and what part each employee plays in it. Every man should be made to feel that he is a member of a team. One way to do this is to train men for foremen's jobs. Promotion from within the plant's forces should be a company policy and then practiced. It should be realized that men have a basic need for self-expression and a desire for self-respect.

In the session devoted to semiconductors, P. N. Russell, General Electric Company, presented a paper on developments in the field of ferrites and what this class of materials could do in the field of electronics. "Recent Developments in Silicon Diodes and Transistors" was the subject of Jay Thornhill's paper, which was a progress report on work done in the Texas Instrument Company.

An automobile radio receiver in which nine transistors replaced the usual vacuum tubes was described by L. A. Freedman of the Radio Corporation of America (RCA) Laboratories. In emphasizing its low power consumption, he pointed out that more than half the small amount of current required by the set was used for two small dial pilot lights. Although designed for a 6-volt automobile battery, it can be adapted to a 12-volt battery installation. This transistorized receiver has performed satisfactorily at temperatures between −40 F and +176 F.

A small semiconductor that converts either visible light or atomic radiation directly into usable electric energy was described by E. G. Linder, RCA Laboratories. This is a silicon junction similar to those used in transistors and used in experimental solar and atomic batteries. Research is being carried on with the idea that such devices may be used for supplying power to instruments and other apparatus which have a low power consumption.

Problems peculiar to the paper and pulp industry were covered in five District papers. Two of these were on electric drives for paper-making machinery; one described a magnetic flow meter and its use in the paper-making field; another covered uses of magnetic amplifiers; and the last paper concerned a gas turbine and how it was used in a paper mill.

Seven District papers on atomic energy and its instrumentation were given in two sessions. H. A. Lamonds, North Carolina State College, described the boiling-water reactor at his school and the course in nuclear engineering which had been established in 1950. This is the first privately owned reactor and since 1953 it has been used in the training of nuclear engineers, providing experience in reactors, kinetics, control problems and techniques, critical assemblies, calibration, etc.

"Recent Developments in Nuclear Instrumentation" were discussed by F. M. Glass of Carbide and Carbon Chemicals Company. He described linear pulse amplifiers which

are used in the measurements of half-lives of materials; a double delay line linear amplifier, with a gain of 40,000; a count-rate meter, covering from 100 counts to 1,000,000 per minute; and a personal alarm monitor, which sounds off when radiation reaches harmful proportions.

In a session on television and microwaves, L. R. Fink, General Electric Company, explained the fundamentals of color television, the problems encountered in the developing of the picture tube for the receiver, and discussed production and marketing problems with which manufacturers are faced.

Student Prize Papers

The Student Council for District 4 reported that about 175 students from colleges and universities throughout the southern area were at the meeting and were given an opportunity to become acquainted with the working of the Institute and its members. Papers were presented by the students in competition. Judges were Professors C. R. Vail, Duke University; F. T. Tinsley, Clemson Agricultural College; and E. R. Weston, Georgia Institute of Technology.

Winners of the competition were as follows:

First prize: R. H. Dietz, Jr., University of Alabama, for "A Nonlinear Resistance-Inductance Oscillator."

Second Prize: W. D. Ashcraft, Clemson Agricultural College, for "Miniaturization and Improvement of a High-Quality Sound System."

Honorable Mention: T. L. Stephens, North Carolina State College, for "Electroencephalography," and C. M. Weems, Jr., Georgia Institute of Technology, for "A Very-High-Frequency Spectrum Generator."

Committee Chairmen

Members of the 1955 Southern District Meeting Committee were headed by the following chairmen: I. L. Garcia, general chairman; J. D. Hicks, vice-chairman; N. Patterson, secretary; Don Knauss, treasurer; ladies' program, Mrs. Amy Thompson; finance, G. L. Kenny, Jr.; technical program, Ben Darlington; publicity, M. O. Hollis; student activities, Perry Gibbons; hotel arrangements, W. V. Bracken; registration, T. F. Thompson, Jr.; banquet and social, R. E. Raymond; trips and transportation, J. H. Rose; and printing and tickets, B. R. Gaffner.

Conference on Magnetism, Magnetic Materials, Will Be Held Next Month in Pittsburgh, Pa.

THE FIRST national Conference on Magnetism and Magnetic Materials will be held at the William Penn Hotel, Pittsburgh, Pa., June 14–16, 1955. It is under the auspices of the AIEE Magnetics Subcommittee in cooperation with the American Institute of Mining and Metallurgical Engineers and the American Physical Society.

The purpose of the conference is to provide an opportunity for the presentation of papers and discussion of both the theoretical aspects of magnetism and its practical applications. The broad scope of the program, combined with the exhibits, will for the first time provide a common meeting ground for people of widely different interests—such as manufacturers, fabricators, users, and research personnel in all of these fields.

Although no formal trips have been scheduled, it is assumed that persons interested in visiting facilities in the Pittsburgh district can readily do so by making arrangements with interested parties.

Plans are to publish all conference papers and formally written discussions. Details, such as publication price and date, will be made available at the conference.

Reservations for hotel rooms should be made directly with the William Penn Hotel.

Conference Committee

General Conference chairman and chairman of the program committee is R. M. Bozorth. Other chairmen are: A. C. Beiler (East Pittsburgh) and E. H. England (Pittsburgh), arrangements; J. A. Osborn, exhibits and tours; G. F. Pittman, finance; M. P. Getting, Jr., publicity; and W. J. Wartinbee, registration. W. H. Osterle is treasurer, his alternate, H. W. Colborn. Manager of exhibits is R. Rimbach of Richard Rimbach Associates, Inc.

Tentative Technical Program
Conference on Magnetism, Magnetic Materials

Tuesday, June 14

8:00 a.m. Registration. William Penn Hotel

9:00 a.m. Session I, Basic Magnetism

J. E. Goldman, presiding

Opening Remarks and Welcome. R. M. Bozorth, Conference Chairman

Magnetism and Electronic Structure. *H. Brooks*, Harvard University

The Process of Magnetization. *C. P. Bean.* General Electric Research Laboratories

Some Considerations on Double Exchange. *P. W. Anderson*, Bell Telephone Laboratories; *H. Hasegawa*, University of Tokyo

The Role of Covalence in Oxides Containing Manganese. *J. B. Goodenough*, Massachusetts Institute of Technology

Collective Electron Model for Magnetization in Alloys. *B. R. Coles, J. E. Goldman*, Carnegie Institute of Technology

Two-Level Approach to Co-operative Phenomena. *J. Rothstein*, Signal Corps Engineering Laboratories

Magnetic Properties of Beta—UH_3. *S. T. Lin, A. R. Kaufmann*, Massachusetts Institute of Technology

Magnetic Properties of Pure Superconductors. *N. Muench, T. S. Teasdale, J. Thompson, C. F. Squire*, Rice Institute

Ultrasonic Absorption in Superconducting and Normal Tin at Low Temperatures. *H. E. Bommel*, Bell Telephone Laboratories

2:00 p.m. Session II. Magnetic Susceptibility and Resonance Phenomena

R. M. Bozorth, presiding

Susceptibility Measurements on Paramagnetic Spinels and Metals at Very Low Temperatures. *A. Arrott, J. E. Goldman*, Carnegie Institute of Technology

The Saturation Magnetic Moments in Iron-Aluminum Alloys. *M. T. Pigott*, The Pennsylvania State University

Spin Wave Resonance in Ferromagnetic Metals. *G. T. Rado, J. R. Weertman*, Naval Research Laboratory

The Frequency Dependence of g-Values in Polycrystalline Ferrites. *T. R. McGuire*, Naval Ordnance Laboratory

The Magnetic Susceptibility of Impurity Trapped Electrons and Holes in Semiconductors. *E. Mooser*, National Research Council

Powder Susceptibility of an Antiferromagnet. *J. R. Tessman*, The Pennsylvania State University

Magnetic Moment Arrangements and Magnetocrystalline Deformations in Antiferromagnetic Compounds. Y. Y. Li, Carnegie Institute of Technology

Strong Field Magnetization of $CrCl_3$ at Low Temperatures. *W. E. Henry*, Naval Research Laboratory; *M. Griffel, W. N. Hansen*, Iowa State College

Domain Walls in Antiferromagnetics and the Weak Ferromagnetism of Alpha Fe_2O_3. *Y. Y. Li*, Carnegie Institute of Technology

Magnetic Susceptibilities of Complexes of the Transition Elements. *M. Wolfsberg, N. Elliott*, Brookhaven National Laboratory

Low-Temperature Heat Capacities of Some Normal Spinels. *S. A. Friedberg, D. L. Burk*, Carnegie Institute of Technology

Diamagnetism of Free Electrons in Aromatic Lattices. *H. T. Pinnick*, University of Buffalo

Static and Dynamic Magnetization Characteristics of Magnetic Amplifier Core Materials. *E. Both*, Signal Corps Engineering Laboratories

Wednesday, June 15

9:00 a.m. Session III. Metallurgy and Structure

C. M. Zener, presiding

Metallurgy of Magnetic Materials. *J. F. Libsch, G. P Conard*, Lehigh University

A Contribution of the Study of Ferrous Ternary Diagrams to Magnetic Interactions. *U. H. Roesler*, Westinghouse Research Laboratory

Domain Configurations and Crystallographic Orientation in Grain-Oriented Iron-Silicon Alloy. *T. G. Nilan, W. S. Paxton*, U. S. Steel Research Laboratory

Effects of Stresses on Losses and Domain Configurations of Grain-Oriented 3-Per-Cent Silicon-Iron. *P. W. Neurath*, General Electric Company

Low-Temperature Precipitation in Commercial 3-Per-Cent Silicon Steels. *F. S. Gardner*, General Electric Company

Magnetostriction of Iron-Silicon Alloys in High Fields. *B. A. Calhoun, W. J. Carr, Jr.*, Westinghouse Research Laboratories

Deformation and Recrystallization of 3-Per-Cent Silicon-Iron. *G. Wiener, R. Corcoran*, Westinghouse Research Laboratories

Some Notes on Ferromagnetic Properties of Alloy with Superlattice. *H. Sato*, Westinghouse Research Laboratories

Dislocation Movements in a Stress-Relief Anneal and Their Relation to Magnetic Recovery. *C. G. Dunn*, General Electric Company

Powder Metallurgy for Research into Ferromagnetic Materials. *C. E. Richards, E. V. Walker, A. C. Lynch,* Post Office Engineering Department (London)

Magnetic Materials and Powder Metallurgy. *H. Evans, C. G. Smith, D. K. Worn,* Mond Nickel Company Ltd.

2:00 p.m. Session IV. Permanent Magnets and Fine Particles

J. A. Osborn, J. F. Libsch, presiding

Recent Advances in the Field of Permanent Magnets. *K. J. Sixtus,* Indiana Steel Products Company

The Electron Microscopy of Submicron Iron Particles. *J. H. L. Watson,* Henry Ford Hospital; *M. W. Freeman,* M. W. Freeman Company

Effect of Shape Anisotropy on the Coercive Force of Elongated Single Magnetic Domain Iron Particles. *T. O. Paine, L. I. Mendelsohn, F. E. Luborsky,* General Electric Company

An Approach to Elongated Fine Particle Magnets. *I. S. Jacobs, C. P. Bean,* General Electric Research Laboratories

Permanent-Magnet Properties of Elongated Single-Domain Iron Particles. *L. I. Mendelsohn, F. E. Luborsky, T. O. Paine,* General Electric Company

Preferred Orientation and Magnetic Properties of Rolled and Annealed Permanent-Magnet Alloys. *W. R. Hibbard, Jr.,* General Electric Research Laboratories

BiMn "Spire" Growth Induced by a Magnetic Field. *B. W. Roberts,* General Electric Research Laboratories

Observation of the Magnetic Domains and Domain Wall in BiMn by the Kerr Magneto-optic Effect. *B. W. Roberts,* General Electric Research Laboratories

The Anomalous Behaviour of Alnico V in the Sub-Curie Temperature of 1,000–1,450 F. *J. R. Hansen,* Crucible Steel Company

New Facts Concerning the Permanent-Magnet Alloy, Alnico V. *E. A. Nesbitt, H. J. Williams,* Bell Telephone Laboratories

2:45 p.m. Session IV-A. Magnetic Amplifiers and Switching

A. C. Beiler, presiding

The Noise Problem in the Coincident-Current Memory Matrix. *J. D. Childress,* Massachusetts Institute of Technology

The Influence of Pulsed Magnetic Fields on the Reversal of Magnetisation in Square-Loop Metallic Tapes. *D. S. Rodbell, C. P. Bean,* General Electric Research Laboratories

Relation of D-C Magnetic Properties of Oriented 48 Per Cent Nickel-Iron to Magnetic Amplifier Performance (AIEE paper 55-455). *M. F. Littman, C. E. Ward,* Armco Steel Company

Soft Magnetic Materials with Rectangular Hysteresis Loops. *N. I. Ananthanarayanan,* Westinghouse Electric Corporation

Magnetostriction in Ferrites Possessing a Square Hysteresis Loop. *P. K. Baltzer,* Massachusetts Institute of Technology

Rotational Damping in a Thin Ferromagnetic Disk. *T. L. Gilbert, J. Kelly,* Armour Research Foundation

Dynamax, A New Crystal and Domain-Oriented Core Material. *G. H. Howe,* General Electric Research Laboratories

Topics in the Microwave Applications of Ferrites. *J. Cacheris, G. Jones, R. Van Wolfe,* Diamond Ordnance Fuze Laboratories

Thursday, June 16

9:00 a.m. Session V. Ferrites.

W. F. Meiklejohn, presiding

Ferromagnetics and Ferroelectrics. *A. von Hippel,* Massachusetts Institute of Technology

Applications of Ferrites. *V. C. Wilson,* General Electric Research Laboratories

Recent Developments in Microwave Ferrite Devices. *S. Weisbaum,* Bell Telephone Laboratories

Ionic Distribution in Ferrites. *H. B. Callen,* University of Pennsylvania; *S. W. Harrison, G. J. Kriessman,* Remington Rand

Initial Permeability as a Function of Temperature for Certain Ni-Zn Ferrites. *J. M. Blank, N. Schwartz,* General Electric Company

Magnetic Anisotropy of Cobalt Ferrite and Nickel Ferrite. *H. Shenker,* Naval Ordnance Laboratory and University of Maryland

Initial Permeability in Ferrimagnetic Spinels. *R. S. Weiss,* Radio Corporation of America

The Effect of Minor Additions of Manganese or Cobalt in High-Resistivity Nickel-Ferrites. *L. G. Van Uitert,* Bell Telephone Laboratories

2:00 p.m. Session VI. Apparatus and Magnetic Design

M. P. Getting, Jr., presiding

Interrelation of Manufacture, Magnetic Properties, and Engineering Design of Magnetic Apparatus. *T. J. Murrin,* Westinghouse Electric Corporation

Magnetic Effects of Compressional Stress at Low Field Intensities. *R. E. Fischell,* Naval Ordnance Laboratory

The Effect of Fringing of Air Gaps in Hipersil Cores *A. S. Poulsen,* Westinghouse Electric Corporation

A New Low-Field Magnetometer for Measuring H of Small Soft Magnetic Specimens. *R. D. Robinson, P. G. Frischmann,* General Electric Research Laboratories

Effect of Temperature on the Permeability and Core Loss of Electrical Steels. *J. J. Clark,* Westinghouse Electric Corporation

Stability Characteristics of Molybdenum Permalloy Powder Cores. *C. D. Owens,* Bell Telephone Laboratories

An Accurate Electronic Tracer for Dynamic Characteristics of Magnetic Materials (AIEE paper 55-454). *E. Kittl,* Signal Corps Engineering Laboratories

The Synthalizer System; An Automatic A-C B-H Loop Recorder. *E. R. Czerlinsky, R. MacMillan,* Air Force Cambridge Research Center

A Vibrating Coil Magnetometer and Its Application to the Study of the Curie Point of Magnetite. *D. O. Smith,* Massachusetts Institute of Technology

Radio-Frequency B-H Tracer and Power Measurements of Ferrites. *B. Christensen,* Westinghouse Electric Corporation

In addition to four technical sessions, a cocktail party will be held on Monday, June 2, 6:30 p.m., at the Penn Sherwood ($3.00 per person).

Registration for the conference will take place in the lobby of the Penn Sherwood, as well as in the Physics Building of The University of Pennsylvania, 8:30 a.m., June 2.

The tentative technical program follows:

Thursday, June 2

8:30 a.m. Registration

9:00 a.m. Introductory Remarks

Introduction of session moderators and keynote speaker M. A. Rudner

Speaker: General E. R. Petzing

9:15 a.m. Magnetic Materials

Presiding: S. C. Spielman, Philco Corporation

Materials Aspects in New Electronics. *A. E. Middleton,* P. R. Mallory and Company

Modern Magnetic Ferrites and Engineering Applications. *C. D. Owens,* Bell Telephone Laboratories, Inc.

Relaxation, Resonance, and Related Phenomena in High-Permeativity Polycrystalline Ceramics. *H. M. Schicke,* Allen-Bradley Company

High-Impedance Ferrite Delay Lines. *H. W. Katz,* General Electric Company

A New Method of Determining the Factor of Merit of Powdered Iron and Ferrite Cores. *H. Drassal,* Stackpole Carbon Company

Core Loss Measurements With a Radio-Frequency B-H Tracer. *Bent Christensen,* Westinghouse Electric Corporation

2:00 p.m. Dielectric Materials

Presiding: A Christopher, Bell Telephone Laboratories

European Developments in Dielectric Materials. *G. de Senarclens,* Swiss Insulating Works

Magnesium Oxide Insulating Coatings. *Lydian Suchoff,* Signal Corps Engineering Laboratories

New Uses of Integrated Mica. *M. D. Heyman,* Integrated Mica Corporation

The Mechanical Engineering of Dielectrics. *Bryce Maxwell,* Princeton University

Tantalum and Tantalum Electrolytic Capacitors. *R. J. Henry, S. S. Fry,* Fansteel Metallurgical Corporation

Metals and Materials for Resistors and Capacitors. *A. E. Middleton,* P. R. Mallory and Company

6:30 p.m. Cocktail Party

Friday, June 3

9:00 a.m. Insulating Materials

Presiding: D. C. Bowen, Radio Corporation of America

Surface Resistivity of Ceramic and Organic Materials at High Relative Humidity. *J. C. Williams, D. B. Herman,* Bell Telephone Laboratories

Improved Water-Repellent Dielectric Materials. *T. J. Dietz, C. A. Liddicoat, C. L. Petzu, Jr.,* Delaware Research and Development Corporation

Moisture Resistance and Dielectric Breakdown of Solid Electrical Insulating Materials. *J. Chapman, L. Frisco,* Johns Hopkins University

Copper-Clad Kel-F—A Versatile New Material. *S. J. Stein, L. B. Allen,* International Resistance Company

Forming of "Teflon" for Electrical Uses. *R. L. Hibbard,* The Joclin Manufacturing Company

New Developments in the Silicone Family. *D. F. Christensen,* Dow Corning Corporation

2:00 p.m. Application of Materials to Components

Presiding: J. T. Brothers, Philco Corporation

Ferroelectrics and Their Application as a Memory. *C. W. Pulvari,* The Catholic University of America

Electronic Materials and Components Conference Is Scheduled for June 2–3

The Electronic Materials and Components Conference will be held in Philadelphia, Pa., June 2–3, at the Penn Sherwood Hotel. It is intended that the conference will be held biennially to present latest information on materials and components to the engineer. A carefully selected and integrated program covering magnetic materials, dielectric materials, insulation materials in general, and the application of these materials to various types of components will be discussed during the four sessions.

The conference is under joint sponsorship of AIEE and the Institute of Radio Engineers. This combined sponsorship assures adequate representation of several areas of interest within the field of electronic materials and components.

Applications of Crystal Chemistry in the Search for Superior Ferroelectric Materials. *E. C. Henry*, General Electric Company

Cadmium Sulfide—Semiconductor of the Future. *L. L. Antes*, Wright Air Development Center

Techniques for the Utilization and Modification of Encapsulating Resins. *E. G. Linden, Pierre Townend*, Signal Corps Engineering Laboratories

Studies of Adhesive and Conformal Coatings Used in Fabrication of Printed Circuitry. *Virgil Lorentzini, R. M. Houghton*, Houghton Laboratories

Laminates for Printed Circuits. *N. A. Skow*, Synthane Corporation

Application of "Teflon" Insulated Wire in the Electronics and Aircraft Industries

Pacific General Meeting Scheduled for August 15-18 in Butte, Mont.

THE AIEE PACIFIC GENERAL MEETING will be held in Butte, Mont. at the Finlen Hotel, August 15–18, 1955. Plans are being made for an interesting and unusual meeting with a complete technical program, enjoyable field trips, and entertainment. Every guest will have the opportunity to return home with pleasant memories of Western hospitality, mountain scenery, and cool nights.

The Technical Papers Committee is planning to present 60 papers in parallel sessions on an accurately timed basis.

A coffee hour will be held for the ladies each morning in the Finlen Hotel Roundup Room, and there will be an informal tea Tuesday afternoon, and a luncheon Wednesday noon.

Registration will begin at 3:00 p.m., Sunday, August 14, and will continue through Tuesday. Tickets for all events will be handled at the registration desk.

Entertainment and Sports

An informal Western outing will be held on Monday evening, August 15, at Columbia Gardens, near the top of the Continental Divide. Following the hospitality hour and outdoor dinner will be a mixer dance, square-dancing, exhibits, and entertainment. Tuesday evening is open for visiting Butte's famous steak houses or for a visit to Virginia City. On Wednesday, activity will be centered at Butte Country Club for golf, tennis, swimming, and an informal dinner-dance.

Virginia City is 89 miles from Butte. Stores, print shops, drug stores, the Wells Fargo office, etc., are all stocked with original merchandise and furnishings. In the evening, there is "Vodvil" and "Melle-drama," presented in the "Virginia City Playhouse." Other side trips will be available to Lewis and Clark Caverns, dude ranches, and fishing streams.

Inspection Trips

Kelley Shaft, Anaconda Copper Mining Company. This is the world's largest mining shaft. The two d-c electric hoists for handling ore and supplies are 3,000 hp and 2,500 hp. From 12,000 to 15,000 tons of copper ore are brought to the surface daily through this opening which is the hub of the $25,000,000 Greater Butte Project. Trips will be made hourly during the meeting to give everyone an opportunity to see both surface and underground installations.

Anaconda Smelter. Daily trips will be made to inspect the Anaconda smelter located 26 miles from Butte. The world's largest copper smelter has many electric installations of interest.

Several other electric installations will be available for inspection by those who can include them in their traveling itinerary. A map of the highways and locations will be available for planning these side trips.

Hotel Reservations

Hotel reservations should be sent to R. J. Labrie, Hotel Committee Chairman, 2725 St. Ann Street, Butte, Mont. Mr. Labrie wants those who are sure of attending the meeting to write him describing minimum requirements. (This would be before regular registration forms are mailed.) All reservations will be made through the hotel committee.

Committee

The General Committee chairman is W. H. Mott, who is being assisted by R. C. Setterstrom, vice-chairman; Dean E. W. Schilling, technical program; Mrs. C. A. Champ, Ladies' Committee; N. V. Anderson, transportation and inspection trips; R. J. Carlson, entertainment; D. E. Kampschror, secretary; R. J. Labrie, hotels and registration; R. C. Nealey, finance; Professor Dale Schekles, students; and W. H. Blankmeyer, publicity.

ANACONDA COPPER MINING COMPANY'S smelter is 26 miles from AIEE Pacific General Meeting headquarters, Butte, Mont. Trips through the smelter will be scheduled for delegates during the meeting. Ore is brought to the smelter by electrified railroad.

Aluminum Conference a Success; Proceedings to Be Published

A successful conference on the uses of aluminum in the electrical industry was held in Pittsburgh, Pa., March 15–17, with an attendance of 585. This was the first national conference of its kind. Papers were presented covering the uses of aluminum in switchgear, transformers, regulators, reactors, rotating machines, cables, transmission and distribution conductors, and other miscellaneous applications. Conference headquarters was the William Penn Hotel.

I. W. Wilson, president of the Aluminum Company of America, was principal speaker at a banquet held on the second day of the conference. His subject was "Man's Distinctive Mark."

All of the utility companies reported use of aluminum conductors in either transmission or distribution systems. Many companies are using aluminum conductors in both. A common problem to which considerable discussion was devoted throughout the conference was that of connections between copper and aluminum. Several authors reported results of extensive tests on this matter. One significant fact is that it appears that there is no one best method for connecting copper and aluminum. There is still difference of opinion among various utility companies on whether copper or aluminum body connectors, and whether silver plating or tin plating or no plating, should be used.

One company reported intermixing of aluminum and copper on distribution lines, Another reported it may extend a coppered conductor line with aluminum. But, where a replacement of a section on a circuit is required the conductor of like kind is used.

CONFERENCE COMMITTEE for the Aluminum Conference were (left to right): L. W. Tarn, R. S. Gardner, J. E. Lange, C. T. Hatcher, B. G. A. Skrotzki, E. S. Reeser, R. N. Wagner, W. J. Wartinbee, W. H. Osterle, and D. N. Reps. Also on the committee, but absent when picture was taken: E. W. Brewer and R. F. Lawrence. See meeting report, pp. 537–8.

One of the papers covered tests being made in certain areas of the country on the amount of corrosion occurring between steel core and aluminum strands of aluminum cable steel reinforced (ACSR) conductors. It was reported that at the present time no clear-cut picture of core protection methods has emerged.

Regarding the use of aluminum in reactors and transformers, the authors of two papers on reactors were in general agreement on a number of specific points: (1) Aluminum is attractive for use in reactors and the use of aluminum may result in a slightly larger reactor for the same loss characteristics. (2) The undesirable characteristic of high-resistance oxide film for most electrical applications is an advantage in insulating the individual cable strands, thus reducing losses due to the heavy field cutting individual strands on the reactor applications. (3) The connector problem for aluminum or copper cable on reactors requires special attention using either a torch or shielded arc process.

Aluminum is feasible in distribution transformers and dry-type transformers, as covered by the authors of three papers. Obstacles to more general use seem to be: higher costs of rectangular wire; need for new manufacturing techniques; and revision of joining techniques. Adequate aluminum connections can be made, but require special apparatus and techniques in production.

Inspection trips were arranged and were all well attended. Proceedings of the conference will be published and may be obtained from AIEE Headquarters, 33 West 39th Street, New York, N. Y., at $3.50 per copy, postpaid.

Crane Conference Papers, Discussions Are Being Published

All papers and discussions presented at the Electrical Overhead Cranes Conference last March in Cleveland, Ohio, are being published in book form. This book can be purchased from AIEE Headquarters, 33 West 39th Street, New York, N. Y., at $3.00 each, postpaid.

The papers cover overhead traveling cranes, grab buckets, and overhead collector systems. (See March *Electrical Engineering*, page 256, for technical program.) A discussion followed each session with many members and guests participating. The conference was sponsored by the Materials Handling Subcommittee of the Institute's General Industry Applications Committee.

'55 Southern Textile Conference A Success; Plans Made for 1956

Another successful Southern Textile Conference took place March 3–4. Approximately 150 persons attended technical sessions at the North Carolina State College Auditorium, Raleigh. Subjects covered equipment and how it is to be used in plant expansion and modernization, and also standard maintenance problems. A panel discussed general mill electrical problems and questions were asked by the audience.

Victor Sepavich, chairman of the Textile Subcommittee of the Committee on General Industry Applications, presided at the subcommittee meeting, March 3. Plans were made for the 1956 conference to take place in Atlanta, Ga., March 1–2. These tentative plans include having National Electrical Manufacturers Association representatives and subcommittee members outline the work that has been done on electrical enclosures, methods of operation, and other pertinent electrical data. Other parts of the program will deal with textile engineering problems, d-c rotating equipment, and d-c control maintenance.

Providence Section Sponsors Student Branch Competition

AIEE's Providence Section sponsored a student paper competition in conjunction with Student Branches at the University of Rhode Island (URI) and Brown University, on the Rhode Island University Campus, March 17. Winners were: D. E. Speliotis, first place (URI), "Skin Effect: A Mathematical Development"; E. E. Bliamptis, second place (URI), "Stability of Servomechanisms"; J. C. Davis, Jr., third place (Brown), "An Inexpensive Laboratory Voltage Regulator"; and D. P. Hynek, honorable mention (URI), "A Tube Numbering System."

The competition was judged on an individual basis, as would be the case if all the papers came from one institution. The first, second, and third place winners received Providence Section awards and the highest student from each institution won his Branch competition. Branch winners competed in the District contest in April.

The Providence Section invited all members of both Branches to be guests for dinner at the annual Student Night meeting, May 10, when prizes of $15.00, $10.00, and $5.00 were awarded.

Missouri School of Mines Branch Closes an Active Year

The AIEE–Institute of Radio Engineers Missouri School of Mines Student Branch at the University of Missouri has ended an active year, and on March 3 an election for the coming year was held. William Hygh was elected chairman. At the same meeting a film, "The Eager Mind" from Westinghouse, was shown.

On March 30 the local student paper contest was held. Morton Mullins, a junior, won first prize for "The Photo-Multiplier Scintillation Counter." Later (in April) he won the District 7 AIEE Student Paper Contest at Lawrence, Kans.

The Branch ended the school year with the annual senior banquet Thursday, May 5. Dr. R. J. Koopman of Washington University, guest speaker, spoke about "The Use of Computers in Industry." More than 100 students, faculty members, and their wives were in attendance. Campbell Barnds, Branch chairman during the past year, was given an award for being an outstanding electrical engineering student. (See page 543 for pictures.)

Brig. Gen. S. E. Reimel Retires as Secretary of EJC

The resignation of Brigadier General Stewart E. Reimel (retired), of Washington, D. C., as secretary of Engineers Joint Council (EJC), has drawn from the Council a resolution of regret over the resignation and of appreciation of his "wise guidance and skillful diplomacy" in advancing the prestige of the organization. General Reimel has been

succeeded by E. Paul Lange, who had been assistant secretary. E.J.C.'s resolution is as follows:

"Engineers Joint Council receives with regret the resignation of General Stewart E. Reimel effective April 1, 1955. In accepting this resignation, Council desires to record its deep appreciation to General Reimel for undertaking the post of Secretary on April 16, 1954, at a critical time and at a sacrifice of his personal interests. The wise guidance and skillful diplomacy of General Reimel have contributed greatly to the development and prestige accorded Engineers Joint Council. The Board of Directors is glad to note that Council will continue to have General Reimel's talents available as Secretary of its important Committee on International Relations, and it takes this occasion to wish him well in all of his activities in the future."

Nuclear Congress, Atomic Exposition Will Take Place December 12–17

Under the leadership of Engineers Joint Council, a dozen organizations, representing more than 250,000 American scientists, engineers, and industrialists, have united in announcing a Nuclear Congress and Atomic Exposition to be held December 12–17 in Cleveland, Ohio. (It had been planned previously to hold this meeting in July. See November *Electrical Engineering*, page 1032.)

In addition to covering the interrelations of all branches of the nuclear sciences and engineering, both events have the active support of private enterprise and government in power and other atomic fields.

The basic objective of the congress is to launch a continuing program of interchange of information on the developing applications of nuclear science by the engineer for vital national benefits involving industry, agriculture, medicine, and the public welfare. Co-sponsors of the congress include: AIEE, American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, American Water Works Association, The Society of Naval Architects and Marine Engineers, American Society for Engineering Education, American Institute of Chemical Engineers, American Chemical Society, American Institute of Physics, American Nuclear Society, and Atomic Industrial Forum.

Sponsors of the forthcoming congress called attention to the stimulus given industry plans by the announcement of the Government that the Atomic Energy Commission has called for proposals by private companies on construction of reactors for industrial purposes. It was stated by the Government that help would be given companies presenting acceptable proposals. Power plants are only one of the many projects of the future to be discussed at the congress.

According to J. R. Dunning, chairman General Committee, Nuclear Engineering and Science, "Timing of the Nuclear Congress and Atomic Exposition has been carefully selected to come as soon as possible after the closed United Nations "Atoms-for-Peace" meeting in Geneva.

"Expected de-classifying of currently restricted information following Geneva meetings, will make possible open discussion and planning at the Cleveland congress, looking toward wider scale peaceful uses of atomic energy."

In announcing the world's first major Atomic Exposition, Professor Dodge, president of the organization directly sponsoring the show, said: "The exposition will for the first time bring together under one roof all the major developments in industry and science related to atomic energy. This includes not only atomic power developments, but also the tremendously expanding applications of atomic by-products in all kinds of industrial fields. Suppliers to the various atomic industries are also being invited to display their latest developments relating to peace-time applications.

"While attendance will be drawn chiefly from management and technical professions, it is planned to open the exposition to the public at certain hours."

Lamme Medal Nominations for 1955 Due December 1

Special attention is directed to the fact that the names of Institute members who are considered eligible for the AIEE Lamme Medal, to be awarded early in 1956, may be submitted by any member in accordance with section 1 of article VI of the bylaws of the Lamme Medal Committee as follows:

"The committee shall cause to be published in one or more issues of *Electrical Engineering*, or of its successors, each year, preferably including the June issue, a statement regarding the Lamme Medal and an invitation for any member to present to the Secretary of the Institute by December 1, the name of a member as a nominee for the medal, accompanied by a statement of his 'meritorious achievement' and the names of at least three engineers of standing who are familiar with the achievement."

Each nomination should give concisely the specific grounds upon which the award is proposed, and also a complete detailed statement of the achievements of the nominee, to enable the committee to determine its significance as compared with the achievements of other nominees. If the work of the nominee has been of a somewhat general character in co-operation with others, specific information should be given regarding his individual contributions. Names of endorsers should be given as specified in the foregoing quotation.

Article V, section 2, specifies that: "The committee in making the award shall carefully observe the limitation imposed by Mr. Lamme, that the recipient must have 'shown meritorious achievement in the development of electrical apparatus and machinery.' This shall be taken to mean that the meritorious achievement must be of such character that it has resulted or will result in the production of substantially improved electrical apparatus or machinery. Any work which meets this requirement is admissible whether it be (a) in development of the theory involved; (b) in development of the characteristics of the materials employed; (c) in development of over-all design; or (d) in development in other ways which results in substantial improvement in electrical apparatus or machinery. The words 'electrical apparatus or machinery' shall be taken to indicate discrete and self-contained devices which may or may not include mechanical moving parts without limitation as to the field of application. They shall not be taken to include transmission or distribution systems as a whole, but rather to include the apparatus and machinery that is used in making up such systems."

New York Section Hears Story of St. Lawrence Power Project

Special feature of the New York Section's annual meeting held April 18 was the engineering story of the St. Lawrence power project. The story was presented by a panel of three speakers. The panel was led by J. Burch McMorran, chief engineer, Power Authority of the State of New York, who described civil engineering and general administrative aspects. The mechanical aspects were presented by George R. Rich, consultant, Uhl, Hall and Rich, Consulting Engineers, and the major electrical aspects were described by John S. Saloma of Uhl, Hall and Rich. The meeting took place in the auditorium of the Engineering Societies Building with J. R. Kerner presiding. Election of new Section officers was also announced at this meeting.

In introducing the subject, Mr. McMorran gave a vivid impression of St. Lawrence rapids and the traffic on the little 14-foot canal as a seaway. The Corps of Engineers made a complete report in 1941, which would have been developed if it had not been for World War II. The watershed in the Great Lakes region is 300,000 square miles and there is a record of flow from Lake Ontario for 19 years. The St. Lawrence is one of the largest constant-flow rivers. The maximum flow is only a little more than twice the minimum; whereas the ratio of maximum to minimum flow of the Columbia River is in the order of 31:1.

Three dams will be constructed—Iroquois Dam, Long Sault Dam, and Barnhard Dam, which will raise the water 90 feet above the present level and provide 2,200,000 hp. Operation will be under the International Joint Commission, which has set up a joint board of engineers to control the flow. The entire project will be comprised of 32 units—16 on the American side and 16 on the Canadian. These units are each rated at

J. B. McMORRAN (center), chief engineer, Power Authority of the State of New York, is shown with some of the members of the New York Section before whom he spoke, April 18. Mr. McMorran's subject was the St. Lawrence Power Project. Left to right are: H. W. Marquardt, assistant program chairman; J. R. Kerner, Section chairman; Mr. McMorran; F. W. Mahley, chairman of the Power and Industry Division; and Martin Lenning, program chairman. The meeting was sponsored by Power and Industry.

NEW SECTION CHAIRMAN, New York Section, Robert T. Weil, Jr. (second from right) is congratulated by J. P. Neubauer, a Vice-President of AIEE. Left to right: R. W. Gillette, secretary; W. A. Clark, vice-chairman; Mr. Neubauer; Professor Weil, and W. T. Rea, treasurer. Announcement of new officers was made during the April 18 meeting.

71,000 hp at 81-foot head. Manufacturers of the turbines and generators are as follows: English Electric Company, Limited; Canadian Westinghouse; Allis-Chalmers Manufacturing Company; General Electric Company; and Baldwin-Lima-Hamilton.

Novel mechanical features of construction, with units spread out along the face of the dam and Gantry cranes to carry them to service buildings at each end of the dam—one on the United States side, the other on the Canadian—were described by Mr. Rich. Turbines are of the fixed-blade impeller type because of the constant flow.

The design of the major electrical features of the St. Lawrence power project were described by John S. Saloma. Installation will be comprised of two busses, 115 kv and 230 kv. Transformers will be located on the draft tube deck as close to the generators as possible because of the high currents of 25,000 amperes.

Generator circuit breakers will be 14.4 kw with an interrupting capacity of 1,500,000 kva. Due to the improvements in present-day lightning arresters, circuit breakers, and insulation co-ordination, the basic insulation level may be lowered to 825 kv. Circuit breakers of 10,000,000-kva interrupting capacity are contemplated.

On the American side, four pipe-type circuits will be used, two 115-kv circuits, and two 230-kv circuits. Power will be on the lines in 1959 and it is expected that existing transmission facilities in the vicinity will be used.

Election of Officers

The report on the ballots received was read and the following were elected officers of the New York Section for 1955–56: chairman, R. T. Weil, Jr.; vice-chairman, W. A. Clark; secretary, R. W. Gillette; treasurer, W. T. Rea; member-at-large, E. K. Murphy; member-at-large, W. G. Vieth.

The following will be officers of the Power and Industrial Division for 1955–56: chairman, J. C. Hoyt; vice-chairman, D. E. Sullivan; secretary, S. H. Grim; treasurer, G. F. Sievers.

Final Estimates Published on 1955 Engineering Graduates

In the April *Electrical Engineering*, pages 348–9, some figures were published from the January 21 *Engineering and Scientific Manpower Newsletter*. The *Newsletter* is issued by the Engineering Manpower Commission of Engineers Joint Council, New York, N. Y., and the Scientific Manpower Commission, Washington, D. C. Final, revised estimates have now been released (April 8 *Newsletter*) and are as follows:

Aeronautical	730
Agricultural	258
Architectural	440
Ceramic	87
Chemical	2,050
Civil	3,840
Electrical	4,835
Engineering Mechanics	12
Engineering Physics	235
General Engineering	540
Geological	210
Industrial	1,290
Mechanical	5,250
Metallurgical	450
Mining	216
Naval Architecture, and Marine	44
Petroleum	640
Sanitary	15
Textile	132
Unclassified	15
Other	280
Total	21,569

It is also reported that the total number of engineering graduates in the Reserve Officers Training Corps will be about 7,200, or 33 per cent of the graduating class.

Fortescue Fellowship Award Announced for 1955–56

The AIEE Charles LeGeyt Fortescue Fellowship Committee has awarded a fellowship for graduate study in electrical engineering during the academic year 1955–56 to Taylor L. Booth.

Mr. Booth, who is from Coventry, Conn., is a student at the University of Connecticut where he will receive his bachelor of science degree in electrical engineering this month. He has been captain of the swimming team, editor of the *Connecticut Engineer*, and participated in other student activities. He will do graduate work at the University of Connecticut in the automatic control systems field.

The Fortescue Fellowship was established through a trust fund set up by the Westinghouse Electric Corporation in recognition of Mr. Fortescue's valuable contributions to the electric power industry and is administered by the AIEE.

Taylor Booth

Student Winners Announced For New York City District

Students from 11 engineering colleges presented technical papers and demonstrations at the New York City District contest held during April 30, 1955, at New York University (NYU), New York, N. Y.

The first joint Students Day of the Institute of Radio Engineers (IRE) and AIEE was held in the Gould Student Center on NYU's University Heights campus.

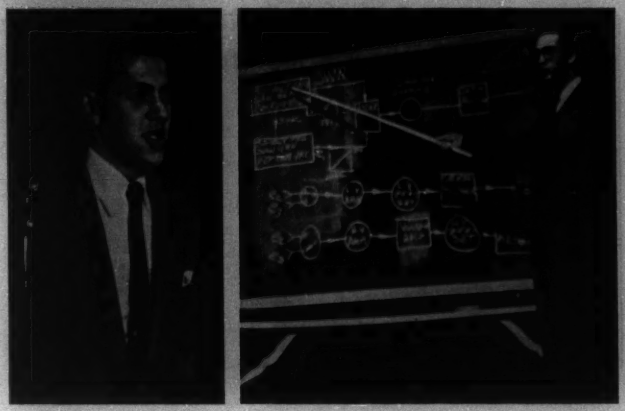
Arvin Grabel, NYU engineering student, took first prize in the technical papers contest for a paper on the linear pulse stretching circuit. Allan Finkel, student at the Newark College of Engineering, had the best demonstration, an exhibit of an electronic curve tracer. Second prize in the demonstration contest went to two Manhattan College students: John Galligan and Samuel Cucinell. Second, third and fourth prizes for papers were won by Harvey P. Lefevre, Manhattan College; Richard Wolfson, NYU, and Victor Wallace, Brooklyn Polytechnic Institute.

The winner of each contest received $50.00 and trips to the Radio Corporation of America Laboratories in Princeton, N. J., and the AIEE Summer General Meeting at Swampscott, Mass. In addition, bronze plaques went to the winners' schools.

About 200 students participated in the event, which was part of the centennial observance of the NYU College of Engineering.

Dean Thorndike Saville of the College of Engineering welcomed participants, and other speakers were: J. L. Callahan of the Radio Corporation of America Laboratories; A. B. Giordano, chairman of the New York Section of IRE; J. P. Neubauer, Vice-President of AIEE; and Colonel R. H. Ranger, of Rangertone, Inc.

Theme of the centennial is "Teaching and Research Build the Future." The 100th anniversary observance began last September with the opening of the academic year.



FIRST PRIZE for the best student paper presented during Student Activities Day, sponsored by the AIEE-IRE Student Branch at New York University (NYU), April 30, went to Arvin Grabel (left) of NYU. His subject: "The Linear Pulse Stretching Circuit." First prize in the demonstration contest went to Allan Finkel (right), Newark College of Engineering, for the "Electronic Curve Tracer." About 200 participated.

AIEE STUDENT BRANCH MEMBERS at Union College, Schenectady, N. Y., assist faculty in welcoming future freshmen to campus. Francis W. Wise (second from right), chairman of the Union College Branch, is explaining a device used in teaching a-c machinery theory at the college.

Villanova Students Hold Two Meetings in March

"Color Television" was the topic at the March 2 meeting of AIEE's Villanova Student Branch. Guest speaker was John Wentworth of the Radio Corporation of America.

Mr. Wentworth explained three fundamental properties of color—hue, brightness, and saturation. Next, he showed how a picture was resolved into a combination of the three primary colors: red, blue, and green. Engineers were greatly concerned with two factors, compatibility and spectrum conversation, he said. These two problems were resolved by four comparatively new ideas: matrixing, band shaping, 2-phase modulation, and frequency interlace.

Guest speaker at the March 16 meeting of the Villanova Student Branch was Edmund Capuzzi, owner of the Polyphase Corporation. Mr. Capuzzi's subject was, "Owning and Running a Small Electrical Business." He listed factors for successfully establishing a new company in the electrical industry and especially stressed the importance of fair dealings with employees. Polyphase Corporation was begun several years ago by Mr. Capuzzi to produce pulse transformers, close-tolerance filters, and transistor analyzers.

Union College Branch Makes "Class of '59 Weekend" Success

AIEE's Student Branch at Union College, Schenectady, N. Y., assisted the faculty in welcoming more than 170 prospective freshmen to the college campus, March 4–6, 1955.

On Friday night, March 4, the future Union students were given an opportunity to visit with the faculty concerned with their particular interests. Student Branch members conducted a tour of the Electrical Engineering Building including the d-c, a-c, and electronics laboratories. Through this tour, an "inside view" of electrical engineering at Union was given.

Various demonstrations were given throughout the building to give the visitors a chance to see a few of the things that can be done with electricity. Activities were concluded with small get-acquainted question-

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until *June 30*. Duplicate double-spaced typewritten copies of each discussion should be sent to Edward C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N. Y., on or before *June 30*.

55-236 Report of Dielectric Tests on a Large Hydrogenerator. *C. A. Duke, C. W. Ross,* and *J. S. Johnson.*

Preprints may be purchased at 30¢ each to members, 60¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to:

AIEE Order Department
33 West 39th Street, New York 18, N. Y.

and-answer sessions between student members and the class of 1959.

The circular device in the lower right-hand corner of the illustration (p. 541) was built in the college's shop. It is for the exploration of the air-gap flux of a synchronous machine at rest with direct current in the armature windings—simulating a particular instantaneous value of alternating current. By choosing different instants or values of direct current flowing in the proper direction and the proper magnitudes in the 3-phase winding of the generator's armature, conditions for various power factors can be duplicated.

Wrist Radio Demonstrated at North Carolina Section Meeting

Dick Tracy's wrist radio—no longer fiction but fact—was shown to AIEE's North Carolina Section members at the Section's spring meeting, March 25. Section members were guests of Western Electric Company, Winston-Salem, N. C., and the North Carolina Mid-State Subsection.

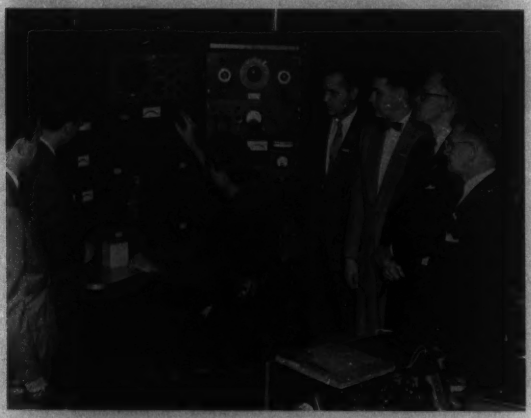
The wrist radio (a small sending and receiving set) was demonstrated by E. A. Bescherer, director of the military branch of Bell Telephone Laboratories at the North Carolina Works. Mr. Bescherer also presented a paper, "Miniaturization—Developments in Components and Application" as part of the technical program. Other speakers were: R. N. Marshall, assistant superintendent, manufacturing engineering, Western Electric Company, "Wave Guide Manufacture"; and J. G. Lawrence, assistant superintendent, field engineering, Navy Operations, "Radar." A tour of the Western Electric plant took place before the program, and F. E. Henderson, manager of North Carolina operations for Western Electric, welcomed members.

Special emphasis was placed on attendance of electrical engineering students from Duke University and North Carolina State College. A student paper, "Electroencephalography" (study of brain waves) was presented as part of the technical program by Thomas L. Stephens, senior in electrical engineering, North Carolina State College. About 25 students from each school attended.

While members attended the technical session, their wives boarded a special bus for a tour of old Salem. Places of interest included the Wachovia Museum, Salem College campus, Home Moravian Church and Cemetery, Reynolda estate and gardens, and the new Wake Forest campus. They then joined the men for dinner and an evening program in the Western Electric Cafeteria.

"Military Electronic Engineering: Research Laboratory to Firing Line" was the subject of the after-dinner talk presented by C. W. Reynolds, assistant works manager. Highlight of the meeting was the presentation of past chairman certificates by C. P. Almon, District 4 Vice-President. Certificates were presented to: Benjamin Martin, H. B. Robinson, Marshall Lake, H. B. Wolf, W. J. Seeley, Otto Meier, Ray Fouraker, G. G. Mattison, and George Stratton. Certificates will be sent to the following chairmen who were not present: W. C. Burnett, F. C. DeWeese, W. H. Brown, E. P. Coles, J. J. Strickland, E. W. Olschner, and H. M. Doerschuk.

The committee responsible for the successful program included: K. T. Knight, W. C. Burnett, W. J. Wortman, A. J. Hill, J. C. Bregar, R. W. Foster, Mrs. Q. T. Brown, Mrs. J. C. Bregar, Mrs. George Hoadley, Mrs. K. T. Knight, and Mrs. H. W. Oetinger.



MAGNETIC AMPLIFIER TEST SET is shown to North Carolina Section members during a tour of the new Western Electric Plant, Winston-Salem, N. C., March 25. The occasion was the Section's spring meeting. Special activities for students and members' wives were also on the program.

Dallas Section Members Hear Electrochemist at Meeting

A pint-size silver-zinc storage battery—now powering the nation's newest and "most important" guided missile, the U. S. Air Force's *Hughes Falcon*—was the topic at AIEE's Dallas Section meeting, April 5. (The 6-foot-long 100-pound *Falcon* is also the nation's smallest guided missile.)

Dr. Paul L. Howard, technical director, Yardney Electric Corporation, New York, N. Y., which pioneered the development of silver-zinc batteries, discussed the operation and performance of Yardney "Silvercels." Dr. Howard is also a former consultant to the Atomic Energy Commission and chief of the Navy's Battery Development Division. The storage cells now are coming into wide use in advanced secret aircraft, missiles, torpedos, and various electronic and instrument applications, he said.

He said that the several Yardney Silvercels used to power the rockets and electronic-guidance system of the *Falcon* are smaller than ordinary cigarette packs and weigh about 3 ounces each. They are rated at three ampere hours, but are capable of much higher rates of discharge.

The *Falcon*—described by Trevor Gardner, U. S. Air Force Assistant Secretary for Research and Development, as "one of the most important contributions to North American defense since the development of radar"—was made possible through the miniaturization of such components, according to Dr. Howard.

AIEE News at The University of Missouri's School of Mines

TELEVISION "STAR" Professor G. G. Skitek (M '53) of the School of Mines and Metallurgy, University of Missouri, Rolla, is shown demonstrating a magnetron oscillator over Station *KOMU*, Columbia, Mo. Professor Skitek and three AIEE–Institute of Radio Engineers Student Branch members at the university were responsible for a 30-minute television program, March 20. Purpose of the program was twofold: to show the people of Missouri what the electrical engineering department at the school teaches, and to entertain the general television audience. The show was written and developed by Professor Skitek who was assisted by the three students: Robert DeWoody, Donald Gessley, and Campbell Barnds. Other equipment demonstrated included: the klystron oscillator, stroboscope, tesla coil, Jacob's Ladder, and cathode-ray oscilloscope.

TWO AIEE MEMBERS were recently initiated into professional membership by the Eta Kappa Nu Chapter at the school. These members are (far left) E. L. Hough (AM '25, F '48), vice-president and chief engineer of Union Electric Company, St. Louis; and (far right) L. J. Linde (AM '39, F '51), director of electrical engineering, Allis-Chalmers Manufacturing Company, Milwaukee, Wis. Others shown are nonmembers who were initiated (left to right): J. W. Stephens, district manager, Missouri Public Service Company, Lee's Summit, Mo.; L. D. Harrison, employment manager, Southwestern Bell Telephone Company, St. Louis; and Hueston M. Smith, president Smith, Hanlon, Zurheide, Levy, Inc., St. Louis.

THE SPRING INSPECTION TRIP of the AIEE–IRE Branch at the School of Mines was held April 2 with 35 members visiting the Sho-Me Power Company's Rolla Substation and the Union Electric Company's Phelp's Substation. Representatives of both companies explained the operation and use of each substation with its relation to the system and the local area. (Also see p. 538.)

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Power Division

Committee on Switchgear (*J. D. Wood, Chairman; J. C. Woods, Vice-Chairman; K. J. C. Falck, Secretary*). The Subcommittee on Power Circuit Breakers has under consideration a proposed new basis for rating power circuit breakers. The new basis requires extensive changes in ASA Standard *C-37*.

It develops and defines a new basic rating term "rated short-circuit current," defines a characteristic which describes both the symmetrical and total (assymmetrical) requirements, permits a simplified method for the application of circuit breakers, and also incorporates test code procedures which insure that the circuit breaker has the necessary interrupting capability.

A preliminary report was presented at the Winter General Meeting in January 1954. In September, the proposal was reviewed and discussed with international standards representatives at an International Electrotechnical Commission meeting in Philadelphia, Pa. As a result of these discussions, the working group has made specific recommendations for changes in Standard *C-37*.

The proposed basis received considerable attention by the Edison Electric Institute–Association of Edison Illuminating Companies–National Electrical Manufacturers Association Joint Committee on Power Circuit Breakers. It was recommended that further study be given to the effect of the new method of rating on applying circuit breakers to transmission systems. Accordingly, a new working group on the application of the proposed basis has been organized under the chairmanship of R. L. Webb. This group has been making a careful study of a variety of applications on actual transmission systems to determine whether or not the new method of rating is suitable. It is hoped that a report from the group will be available for the next subcommittee meeting.

The subcommittee also has under consideration standards for capacitance switching performance, an improved definition of interrupting time, a change in the performance requirements connected with standard duty-cycle standards for generator neutral grounding, and a change in the 4-second rating.

Committee on Insulated Conductors (*M. H. McGrath, Chairman; M. W. Ghen, Vice-Chairman; L. E. Fogg, Secretary*). A 2-day meeting of the committee was held in Cleveland, Ohio, April 12–13, 1955. Progress was reported on a number of projects.

The Subcommittee on Standards and Publications reported that an AIEE Special Publication (*S-73*), "Classified Bibliography on Insulated Conductors," became available in March 1955. The bibliography lists all important technical articles on insulated conductors published in English from 1930 to 1954 in 14 technical journals and five miscellaneous publication groups. A new loose-leaf format classifies references by year and by publication, and at the same time provides classification into both main and subclassifications. The bibliography can be kept up to date by the issuance of pages identical in format.

The Limiter Standardization Task Group of the Accessories Subcommittee reported that eight papers relating to limiter and cable application and co-ordination on secondary networks will be presented at the 1955 Summer General Meeting.

In addition, the committee approved details of an organizational setup for administrative and technical guidance to a $65,000 co-operative research project relating to thermal resistivity characteristics of soils. This project is being sponsored by AIEE, Engineering Foundation, Edison Electric Institute, Association of Edison Illuminating Companies, Insulated Power Cable Engineers Association, certain governmental and municipal agencies, and interested cable manufacturers in the United States and Canada.

Committee on Carrier Current (*S. C. Leyland, Chairman; L. G. Eaton, Vice-Chairman (East); L. E. Ludekens, Vice-Chairman (West); H. W. Lensner, Secretary*). The subject of microwave channels for power system use has been the main interest in recent Carrier Current Committee meetings and technical sessions. A well-attended Microwave Symposium was held at the 1954 Fall General Meeting in Chicago, Ill., and the technical papers at the Winter General Meeting were evenly divided between carrier and microwave.

In addition to microwave, subcommittee activity has been concentrated on methods of measurement at carrier frequencies, and the radiation of carrier energy from power lines. The Methods of Measurement Subcommittee has an extensive field test program planned for this summer. From the results obtained, it is expected that preferred procedures can be set up for obtaining carrier-frequency characteristics of power and carrier equipment.

The Subcommittee on Standards for Carrier Radiation has drafted a proposed standard for limits on carrier radiation and a method of measuring the radiation from power lines. The final report will be presented to the committee for approval at the 1955 Summer General Meeting.

Communication Division

Committee on Television and Aural Broadcasting Systems (*J. B. Epperson, Chairman; C. M. Braum, Vice-Chairman; R. K. Hellmann, Secretary*). Significant progress was made throughout the year in color television. Over-all system performance has been improved by new developments in pickup cameras and associated equipment, intercity microwave circuits, transmitters, receivers with large-screen tricolor kinescopes, and improved test procedures. The committee, through meeting sessions, has been bringing these developments to the attention of members.

Satellite television transmitters, designed to retransmit and boost weak television signals, have received widespread Federal Communications Commission and industry attention. Authorities in the field have described these developments to AIEE members. Also covered by the committee were: broadcast antennas, high-powered broadcast transmitters, propagation, magnetic recording, and high-fidelity amplifiers.

Committee on Special Communications Applications (*E. C. Chamberlin, Jr., Chairman; A. A. James, Vice-Chairman; H. M. Case, Secretary*). As a result of a committee meeting in January some prospects developed which may provide the basis for an interesting session at one of the forthcoming General meetings. It is hoped that recent developments in automatic telephone answering and recording service, and distant-talking telephone equipment will soon be available for presentation to the Institute. In addition, the committee is following up current activity in the field of integrated data processing, railroad communications, aviation controls, and navigation aids.

Science and Electronics Division

Committee on Metallic Rectifiers (*Glen Ramsey, Chairman; D. E. Trucksess, Vice-Chairman; E. A. Harty, Secretary*). The Subcommittee on Technical Information is making a survey of the selenium industry. Purpose of the survey is to obtain data on high-temperature operation in both military and commercial applications of selenium rectifying cells and its effect on their lives. Survey results will be incorporated in panel discussions held during the Summer General Meeting at Swampscott, Mass. The subject of the panel, which is being organized by the Subcommittee on Semiconductors and Rectifying Devices, will be "High-Temperature Operation of Metallic Rectifying Cells." Dr. S. J. Angello will be the moderator. To set the stage for discussion, papers related to the subject will be presented by Messrs. Halvorsen and Henkels.

The Subcommittee on Metallic Rectifiers for Magnetic Amplifiers began activities by developing new definitions required by the use of metallic cells as part of a magnetic amplifier. It was determined that standard test circuits were needed to establish the characteristics of a single cell, as required by the application to magnetic amplifiers. Work was started on circuits for testing the forward, leakage, and dynamic characteristics.

The Power Metallic Rectifier Subcommittee, established the scope to cover "Treatment of Matters Relating to the Design and Applications of Metallic Rectifier Units." This excludes the treatment of components.

A working group was appointed to prepare a policy guide for the assistance of the American representatives to the International Electrotechnical Commission who will have a meeting in London, England, in July 1955.

General Applications Division

Committee on Land Transportation (*R. L. Kimball, Chairman; M. C. Swanson, Vice-Chairman; P. G. Lessmann, Secretary*). This committee had two meetings—one in October 1954 in Chicago, Ill., and one in February 1955 in New York, N. Y. Meetings papers were presented on the latest advances in motive power.

The Subcommittee ASA *C-35* on AIEE Rules No. 11 has finished a draft of revised AIEE Rules No. 11 for rotating electric machinery on railway locomotives, rail cars, etc. This draft is now ready for submission to the committee to approve as tentative standards.

AIEE PERSONALITIES.....

William Firestone (AM '53), group leader, special designs section, Motorola, Inc., Chicago, Ill., has been appointed to the newly created position of assistant chief engineer, research department, Communications and Electronics Division, Motorola, Inc. Dr. Firestone will now have responsibility for specific phases of departmental administration and will also continue in his present position as head of the advanced investigation section of the research department. This group is engaged primarily in vhf 2-way radio research and pulse code development work. He received his Ph.D. in June 1952, from Northwestern University. He is a member of Sigma Xi, Tau Beta Pi, Eta Kappa Nu, Pi Mu Epsilon, and the Institute of Radio Engineers.

R. C. Kirk (AM '45), manager of Kyle products sales for Line Material Company, Milwaukee, Wis., has been promoted to chief engineer, Kyle Products Plant. Kirk succeeds **A. F. Van Ryan** (AM '44), who will continue to serve Line Material Company as a new-product consultant. Prior to his promotion, Kirk had held the sales position since 1950. He originally joined the Kyle organization in 1945 as a division engineer. In 1948 he became apparatus engineer in Line Material's South Central Division. He received the B.S.E.E. and M.S.E.E. degrees from North Carolina State College and is a registered professional engineer in Wisconsin. Van Ryan joined the Kyle Corporation in 1941 after approximately 20 years of switchgear engineering experience. In 1943 he was appointed chief engineer, and when Kyle Corporation merged with Line Material in 1948, he was assigned additional duties as director of new product development. He is a member of the National Electrical Manufacturers Association.

L. W. Long (AM '37, M '44), general manager of Allis-Chalmers Manufacturing Company's Boston Works, has been named general manager, Terre Haute, Ind., Works. Long is being succeeded by **J. F. Chipman** (AM '50), assistant chief engineer, switchgear department. Long joined the firm in 1927 when Allis-Chalmers purchased the Pittsburgh Transformer Company. In 1943 he was transferred from the Pittsburgh Works to the West Allis Works as sales engineer in charge of mixed apparatus sales. In 1947 he became manager of the substation section and in the following year he was named general manager of the Boston Works. He served on the AIEE Power Transmission and Distribution Committee (1946–47) and Substations Committee (1947–48). Chipman began working at the Allis-Chalmers Boston Works in 1936 while attending Northeastern University. Since that time his work has been entirely in the engineering field serving as a laboratory assistant, assistant division engineer in the control section, and assistant division engineer in the oilless breaker section. He was division engineer in this same section from 1946 to 1950. He served as an assistant product engineer from 1950 to 1951 and was named product engineer in 1951. He was appointed to his present position in April 1954.

A. G. Schifino (AM '40), general manager, Sound Division, Stromberg-Carlson Company, has become vice-president, Sound Division, as one of the recent changes in officer titles voted upon by the company's board of directors. Mr. Schifino joined Stromberg-Carlson in 1929. Following 2 years' experience in the telephone laboratory and sales engineering department, he left the company to establish his own business, Sound Equipment Engineering Company, and later the Rochester Radio Supply Company. He severed his connections with the latter in 1940 to rejoin the Stromberg-Carlson Company as chief sound equipment engineer. He became manager of the Sound Equipment Division in 1942, and in 1949 general manager of this division.

P. F. Genachte (AM '35, M '44), official of the Mexican Light and Power Company, has joined the staff of the public utilities department of the Chase National Bank as technical advisor. A native of Belgium, Mr. Genachte is a graduate of the University of Brussels, holds an M.S. degree from Massachusetts Institute of Technology and a Ph.D. from California Institute of Technology. He began his business career in 1935 with Sofina, a utilities holding company with headquarters in Brussels. He was associated with Mexican Light and Power from 1939 to 1945 and again from 1948 to 1952, serving at various times as assistant to the chairman of the board, special assistant to the president, and assistant treasurer. From 1945 to 1948 Mr. Genachte was with the American Intercontinental Trade and Service Company, Inc., in New York, N. Y. In 1952 he joined Indussa Corporation in New York as technical manager and also served as vice-president of the Balteau Electric Corporation in New York. Early this year Mr. Genachte was retained by the World Bank as power consultant on a 2-month mission to Ceylon.

Mrs. R. F. Mankofsky (AM '51), assistant technical service engineer, who has been with Burndy Engineering Company, Inc., for 13 years, has retired. Mrs. Mankofsky, the only woman engineer in a group of over 150 engineers at Burndy, was assigned to an engineering section furnishing technical assistance to the customer, and was involved in many special engineering projects. In addition, she authored numerous technical articles in company and national publications. She is a graduate of Hunter College, class of January 1940. While attending Hunter, she was honored with membership in Phi Beta Kappa and Phi Sigma, a national science honorary fraternity. Mrs. Mankofsky plans to continue her professional society activities in the AIEE and the Society of Women Engineers.

E. W. Kimbark (AM '27, F '48), acting chief, Electronics Division, Instituto Tecnologico de Aeronautica, Sao Jose dos Campos, Sao Paulo, Brazil, has been appointed dean of the school of engineering of Seattle University, Seattle, Wash. He assumed his new duties about May 1. Dr. Kimbark was in Brazil for 4½ years at the Instituto Tecnologico de Aeronautica, a school for members of the Brazilian Air Force and civilians, run by the federal government. He organized and put into operation the Division of Electronics. In addition to his duties in Sao Jose, he gave a series of lectures at the Electrical Engineering Institute, University of Brazil (Rio de Janeiro), and a series of 45 lectures at the Electrical Engineering Institute, University of Sao Paulo. He also is acting as consultant to the latter in the construction of a network analyzer for teaching and consulting work. He has served on AIEE's Basic Sciences Committee (1950–54).

D. F. Hazen, Jr. (AM '41, M '54), traffic manager, Western Union Telegraph Company, Philadelphia, Pa., has been appointed superintendent at Cleveland, Ohio. Mr. Hazen joined the traffic department of Western Union in 1940 following his graduation from the University of Illinois as an electrical engineer. During World War II he served in various combat signal units in the Armored Forces and as division signal officer of the Armored and Infantry Divisions. Following his return to Western Union after the war, he worked on design, maintenance, and personnel training and traffic engineering for the company's nationwide mechanization program. Subsequently, he served on the company's general office staff in New York in various supervisory capacities. Since 1951, he has been traffic manager at Philadelphia. Mr. Hazen is a member of Sigma Xi, Tau Beta Pi, Eta Kappa Nu, and Sigma Tau. He has served in various technical and advisory capacities in telegraph communications problems and is a member of AIEE's Committee on Telegraph Systems (1951–55).

P. H. Trickey (AM '30, F '47), chief engineer of Vickers Electric Division, Vickers, Inc., St. Louis, Mo., has been transferred to Wright Machinery Company, Durham, N. C., another division of the Sperry Corporation, as director of motor engineering. In addition to automatic packaging machinery, Wright is now making synchros and servo motors. Mr. Trickey has served on the following AIEE Committees: Rotating Machinery (1946–55) and Metallic Rectifiers (1953–55).

Abe Tilles (AM '30, F '51), electrical engineer, engineering department, Pacific Gas and Electric Company, San Francisco, Calif., is now professor of electrical engineering at the Technion-Israel Institute of Technology at Haifa. Dr. Tilles was born in New York, N. Y., 1907, and was graduated with highest honors from the University of California in 1928. He has a bachelor of science degree in electrical and mechanical engineering and a master of science and doctorate degrees in electrical engineering—all from the University of California. He taught in the electrical engineering department of this university from 1930–45. He has also worked in the research and industrial design fields for the California State Highway Commission, the Southwest Engineering Corporation, Mare Island Navy Yard, and as senior electrical engineer, Manhattan Project, University of California Radiation Laboratory. In the public utility field he was with the Bureau of Power and Light. He was technical associate of Lester S. Ready, San Francisco utility consultant, 1939. His AIEE activities include work as a Student member at the University of California Branch (1926–28), counselor of the same branch (1936–39), and the following National committees: Student Affairs (1936–39), Summer Meeting (1950, 1954), and Nucleonics (1946–54). He was recipient of the 1936 Alfred Nobel Prize. Dr. Tilles is also a member of Sigma Xi, Eta Kappa Nu, American Society for Engineering Education, American Technion Society, San Francisco Engineers Club, and was founding editor, 1947–49, of the *San Francisco Engineer*. He was also chairman, 1953–54, of the San Francisco Engineering Council.

D. C. Luce (AM '36, F '49), president of the Public Service Electric and Gas Company of New Jersey, will deliver the commencement address at the commencement exercises of Newark College of Engineering, June 9. Mr. Luce has been president of New Jersey's Public Service Electric and Gas Company and Public Service Coordinated Transport since 1954. He has been a member of the board of directors of both companies and on the executive committees of these boards since 1950. Born in Scranton, Pa., May 12, 1900, he was graduated from Lehigh University in 1924 with a degree in electrical engineering. His career in Public Service began the same year when he started with the company as a cadet engineer. In 1936 he was promoted to general superintendent of electric generation. He then successively served as general manager of the electric department, vice-president in charge of electric operation, and vice-president in charge of combined operations.

OBITUARIES

M. R. Hughes (M '47), consulting engineer, Fargo, N. Dak., died recently. Mr. Hughes held a bachelor's degree in mechanical engineering from North Dakota Agricultural College, as well as a bachelor's in electrical engineering from the same college. From 1919 to 1921 he was with W. F. Kurke, architect and engineer in Fargo, as draftsman and construction superintendent for public and private buildings. In 1923 he joined the Northern States Power Company, Fargo. He was draftsman and construction superintendent for Northern States until 1927. From 1928–34 he did part-time work while a full-time student at North Dakota Agricultural College. He was chief draftsman and division engineer for Northern States, 1934–41. He entered the U. S. Army in 1941 as a first lieutenant in the infantry, and in 1946 when he was discharged he was a lieutenant-colonel. After his service with the Army he joined Ulteig Engineering Corporation and in 1950 established his own consulting engineering firm.

E. M. Tingley (AM '00, Member for Life), retired, Oak Park, Ill., died January 11, 1955, after a short illness. He was graduated from Purdue University in 1892, a member of the first electrical engineering class. At Westinghouse he designed electric machinery, working with B. G. Lamme. There he developed the method of fractional-slot winding for a-c machinery and also evolved one of the first formulas for calculation of leakage flux in transformers. During World War I he worked at the Marconi Wireless Company. From 1922 until his retirement in 1937, he was in the research section of the engineering department of Commonwealth Edison Company in Chicago, Ill. One of his most important activities was the direction of field tests on large oil circuit breakers. These were the first practical experiments on equipment of the type to determine their ability to interrupt short circuits, and they served as a background for much of the subsequent development. Following his retirement he devoted considerable time to promoting the use of base-eight arithmetic. He circulated leaflets on this subject and also short papers on a basic approach to "time" and an explanation of "elementary universes."

Hannibal Choate Ford (AM '05, Member for Life), founder of the Ford Instrument Company and inventor of the first mechanical brain for controlling gunfire, died March 12. He was born at Dryden, N. Y., May 8, 1877. In 1894 he worked for the Crandall Typewriter Company, Groton, N. Y. From 1896 to 1898 he was in the experimental department of the Daugherty Typewriter Company, Kittanning, Pa., and for a time in 1898 he was a tool maker for the Westinghouse Electric and Manufacturing Company. In 1899 he entered Cornell University and graduated as an electrical engineer 4 years later. While at Cornell he worked in the electrical engineering laboratory of Sibley College. Later he worked on the Hudson Tunnel and the Manila, Philippine Islands, tramways as an employee of the New York City engineering firm of J. G. White and Company. From 1906 to 1909 he worked for the Smith-Premier Typewriter Company, during which time a number of patents were issued to his credit. In 1909 Mr. Ford assisted Elmer A. Sperry in development of the Sperry gyroscope. When the Sperry Gyroscope Company was set up in 1910 Ford was its chief engineer. He resigned in 1915 to organize the Ford Marine Appliance Corporation. He held the position of vice-president and general manager. A year later the firm was reorganized as the Ford Instrument Company. In 1930 he became its president. In 1930 he also organized the Merrill Aircraft Company and developed an experimental plane which successfully demonstrated at North Beach airport (later LaGuardia field), New York, N. Y., novel features of inherent stability. He became president and director of the Rawnell Holding Company, a real estate concern of Jamaica, N. Y., and a director and organizer of the Jamaica National Bank. Mr. Ford retired from active work at the Ford Instrument Company in 1943. He was a member of the American Society of Naval Engineers, Sigma Xi, and the Engineers' Club of New York, N. Y. He served on AIEE's Marine Committee (1918–19).

Henry E. Richards (AM '25, M '36), professor of electrical engineering and a member of the faculty at Northeastern University, Boston, Mass., for the past 34 years, died suddenly in his home March 4. A graduate of Massachusetts Institute of Technology (MIT) in 1918 with a bachelor's degree and in 1938 with a master's degree, Professor Richards began teaching at Northeastern in 1921. He also taught at Tufts College from 1942–1944 and gave summer courses at MIT in 1944 and 1945. During 1953–54 he served as acting head of the electrical engineering department at Northeastern and he was coauthor of the textbook "Principles of Alternating Current Machinery" by Lawrence and Richards, published in 1953. Prior to entering the teaching profession, he worked on several research projects at the General Electric Company. Well known in engineering circles in the New England area, Professor Richards was a member of Tau Beta Pi, Eta Kappa Nu, American Society for Engineering Education, Engineering Society of New England, and the Professional Engineering Society of Massachusetts.

R. E. Lepperd (AM '51), supervisor, Westinghouse Electric Corporation, Cleveland, Ohio, died recently. Mr. Lepperd was born in 1900 and attended high school in Duncannon, Pa. He attended Bucknell University graduating with a bachelor of science degree in electrical engineering in 1922. He then joined Westinghouse and remained until his death. He rose from tester to control engineer, switchboard and control supervisor, and finally to his position of control engineering supervisor at the manufacturing and repair plant of Westinghouse located in Cleveland. As engineering supervisor, Mr. Lepperd was able to use his background and training and experience accumulated over the years. He was instrumental in helping design various types of steel mill

and coal cleaning plant controls. One of his latest accomplishments was the supervising of engineering and design of control equipment in use at the Ford Motor Company foundry in Cleveland. Mr. Lepperd was working on a complex material-handling setup of electric control equipment for an automotive assembly plant at the time of his death.

Walter Vail Brown (AM '21), retired, former manager of the New York Office of the Engineering Societies Personnel Service, died March 13. He was born in Oldtown, Maine, August 17, 1874. He was a graduate of Chauncy-Hall School, Boston, Mass., and an electrical engineering graduate of the Massachusetts Institute of Technology (MIT) in 1894. After graduation from MIT, Mr. Brown joined Hatzel and Buehler, New York, N. Y., as electrical draftsman. From 1897 to 1906 he was assistant electrical engineer with Pattison Brothers, consulting electrical engineers, New York. He later worked for the Mechanical Department of Water Supply, Gas, and Electricity, Borough of Richmond, New York, N. Y., and still later for the New York Public Library's technology department. In 1918 he was manager of the American Engineering Service and then manager of the Employment Service of The Federated American Engineering Societies. On January 6, 1937, he was given a luncheon at the Engineers' Club "in recognition of his loyalty and efficient service." At this luncheon he was presented with life membership in AIEE. The February 1937 *A.S.M.E.* (American Society of Mechanical Engineers) *News* reported that as manager of the Engineering Societies Employment Service he ". . .played a prominent part in the development of the Employment Service from a so-called clearing house of information regarding engineering positions available to a modern employment service catering to the needs of the membership of the four Founder Societies."

Thomas Rouse Tate (M '24, F '35), consulting engineer on the staff of Charles T. Main, Inc., died at Tampa, Fla., recently. He was born at Eldorado Springs, Mo., June 4, 1888, and graduated with a bachelor's degree in electrical engineering from the University of Missouri in 1912. He held honorary membership in Tau Beta Pi, Eta Kappa Nu, and was past chairman of the Washington Section of AIEE. He was also a member of the American Society of Mechanical Engineers, the American Society of Civil Engineers, the Society of American Military Engineers, the Washington Society of Engineers, and was licensed as a professional engineer in the State of New York. He had been electrical engineer and purchasing agent for McClellen and Junkersfeld, New York, N. Y.; chief engineer and assistant to the president, Trojan Engineering Corporation, New York, N. Y.; chief valuation engineer, Public Utilities Commission, District of Columbia; director of national power survey, Federal Power Commission; and chief, Bureau of Electrical Engineering, Federal Power Commission. Since 1942 he had been Washington representative for Charles T. Main, Inc., Boston, Mass., and had recently returned to the United States after directing the construction of large hydroelectric facilities and transmission lines for that firm in Turkey.

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting of April 21, 1955, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Alberti, J. N., manager, apparatus dept., General Electric Co., Springfield, Mass.
Beal, D. H., engineer, Illinois Telephone Co., Chicago, Ill.
Becken, E. D., asst. vice-pres. & plant operation engineer, RCA Communications, Inc., New York, N. Y.
Beckjord, P. A., manager, customer section, Westinghouse Electric Corp., East Pittsburgh, Pa.
Berry, H. W., research project engineer, Aero Div., Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.
Berry, J. L., supervising electric service engineer, Westinghouse Electric Corp., Seattle, Wash.
Bonner, J., chief test engineer, Reynolds Newbery Joint Venture, Portsmouth, Ohio
Booth, W. G., engineer, Southern Bell Tel. & Tel. Co., Birmingham, Ala.
Borland, M. H., Jr., asst. supt., electric power dept., Mead Corp., Chillicothe, Ohio
Bowden, F. W., head, elec. engg. dept., California State Polytechnic College, San Luis Obispo, Calif.
Carlton, E. E., supervising electrical safety engineer, State of California, San Francisco, Calif.
Center, C. E., technical asst. to project mgr., Atomic Power Div., Westinghouse Electric Corp., Pittsburgh, Pa.
Chapman, J. H., design engineer, Westinghouse Electric Corp., East Springfield, Mass.
Chatterji, B. K., dist. mains engineer, Upper Ganges Valley Electric Supply Co., Ltd., Amroha, India
Clark, W. F., project engineer, Indiana Bell Telephone Co., Indianapolis, Ind.
Clevenger, L. M., field engineer, Philadelphia Electric Co., Philadelphia, Pa.
Courtin, J. J., engineer, Westinghouse Electric Corp., Buffalo, N. Y.
Dahl, T. M., electrical engineer, United Engineers & Constructors, Inc., Philadelphia, Pa.
Dahlgren, C. A., field engineer, U.S. Dept. of Agriculture, REA, Washington, D. C.
Dawson, A. M., manager, General Electric Co., Johnstown, Pa.
Drake, J. H., chief system engineer, Southern California Edison Co., Los Angeles, Calif.
Dugar, V. F., senior project engineer, Reliance Electric & Engineering Co., Cleveland, Ohio
Einwechter, W. S., engineer, Philadelphia Electric Co., Philadelphia, Pa.
Eldridge, E. H., district transformer specialist, General Electric Co., Dallas, Tex.
Erlandson, N. H., transmission engineer, Carolina Power & Light Co., Raleigh, N. C.
Essigmann, M. W., professor of elec. & engg., Northeastern University, Boston, Mass.
Faiman, R. N., professor & chairman, dept. of elec. engg., North Dakota State College, Fargo, N. Dak.
Feil, C. W., district manager, Ohio Power Co., Ironton, Ohio
Friedman, M., engineer, Hertner Electric Co., Cleveland, Ohio
Garrott, W. L., assoc. prof., elec. engg. dept., University of Nevada, Reno, Nev.
Gilson, W. J., Jr., engineer, General Electric Co., Schenectady, N. Y.
Glasco, C. E., chief power pool dispatcher, Interchange Power Services, Inc., Des Moines, Iowa
Glimn, A. F., engineering analyst, General Electric Co., Schenectady, N. Y.
Goldstein, A., chief engineer, special test dept., Brown Boveri & Co., Baden, Switzerland
Gower, S. G., equipment specialist, SAAMA, Kelly AFB, Tex.
Hale, H. W., assoc. prof. of elec. engg., Purdue University, Lafayette, Ind.
Hansberry, J. H., application engineer, General Electric Co., Schenectady, N. Y.
Harmer, L. B., chief engineer, Bermuda Telephone Co., Ltd., Hamilton, Bermuda
Hassler, E. L., senior transmission engineer, Southwestern Bell Telephone Co., Oklahoma City, Okla.
Hazen, D. F., technical consultant, Illinois Power Co., Decatur, Ill.
Heidechi, A. R., chief engineer, Platte Pipe Line Co., Kansas City, Mo.
Heizer, L. O., engineer, Dallas Power & Light Co., Dallas, Tex.
Highfill, W. E., electrical group head, Esso Research & Engineering Co., Linden, N. J.
Hill, H. C., distribution engineer, Georgia Power Co., Atlanta, Ga.
Hodgson R. W., general supervisor, Northrop Aircraft Inc., Hawthorne, Calif.
Hoffer, A. H., design engineer, General Electric Co., Erie, Pa.
Hope, H. W., general manager, Corn Belt Power Cooperative, Humboldt, Iowa
Hopkins, R. J., manager, product engineer, General Electric Co., Hudson Falls, N. Y.
Hottinger, S. E., Jr., municipal engineer, Louisiana Rating & Fire Prevention Bureau, New Orleans, La.
Kennedy, F. H., Jr., vice-pres., The Geotechnical Corp., Dallas, Tex.
Ketelsen, D. F., district manager, Iowa Public Service Co., Le Mara, Iowa
Killiam L. V., staff engineer, The Pacific Tel. & Tel. Co., San Francisco, Calif.
Kitchens, J., electrical engineer, Pacific Gas & Electric Co., San Francisco, Calif.
Kuhl, V. W., Jr., engineer, Florida Power Corp., St. Petersburg, Fla.
Landsman, H., chief engineer, U.S. Hoffman Machinery Corp., Scranton, Pa.
Mackelfresh, G. S., district engineer, Southern Bell Tel. & Tel. Co., Greensboro, N. C.
Marsh, J., owner, Marsh Electric Co., Prescott, Ariz.
Maupin, A. A., Jr., engineer, General Electric Co., Richland, Wash.
Mayfield, W. A., engineer, Sverdrup & Parcel, Inc., St. Louis, Mo.
Mayhew, L. A., electrical engineer, Ebasco Services, Inc., New York, N. Y.
McConnell, H. M., asst. prof. of elec. engg., Carnegie Institute of Technology, Pittsburgh, Pa.
McNamara, J. E., electrical design engineer, U. S. Steel Corp., Pittsburgh, Pa.
Moran, J. H., Jr., engineer, Allis-Chalmers Mfg. Co., West Allis, Wis.
Morris, E. W., switchgear specialist, General Electric Co., Atlanta, Ga.
Murdock, H. W., office manager, General Electric Co., 15 Grove St., Augusta, Maine
Navarrete, A. E., head, electrical engg. dept., Instituto Tecnologico Monterrey, Monterrey, Mexico
Neal, J. P., asst. professor of electrical engg., University o Illinois, Urbana, Ill.
Oorthuys, H. J., asst. professor, school of electrical engg., Purdue University, West Lafayette, Ind.
Pashoogian, S. J., design engineer, Jackson & Moreland, Boston, Mass.
Phillips, R. A., application engineer, General Electric Co., Schenectady, N. Y.
Pickell, J., Jr., appraisal engineer, Southern Bell Tel. & Tel. Co., Atlanta, Ga.
Ramon, L. C., Jr., general foreman, New Orleans Public Service Inc., New Orleans, La.
Reinijes, J. F., associate professor of electrical communication, Massachusetts Institute of Technology, Cambridge, Mass.
Rice, E. K., application engineer, Westinghouse Electric Corp., Albany, N. Y.
Riley, T. M., asst. professor of electrical engg., Norwich University, Northfield, Vt.
Saloma, J. S., associate & electrical engineer, Chas. T. Main, Inc., Boston, Mass.
Sibley, S. L., assistant to vice-president & general manager, Pacific Gas & Electric Co., San Francisco, Calif.
Smith, F. D., division head, Dallas Power & Light Co., Dallas, Tex.
Smith, J. S., supervisor, mobile transmitter engg., General Electric Co., Syracuse, N. Y.
Smith, L. B., chief test engineer, A-C Spark Plug Div., General Motors Corp., Flint, Mich.
Smitheman, E. W., electrical engineer, U.S. Army Corps of Engineers, Middle East District, APO New York, N. Y.
Sprague, C. S., teaching research, Purdue University, West Lafayette, Ind.
Stewart, E. H., Jr., associate engineer, Wesix Electric Heater Co., San Francisco, Calif.
Suprenant, H. A., supt. Western Div., New England Power Co., Shelburne Falls, Mass.
Sutton, A. J., electrical design engineer, B.C. Engineering Co., Ltd., Vancouver, B.C., Canada
Timberman, F. C., manager, Akron branch, Allis-Chalmers Mfg. Co., Akron, Ohio
Trenkle, F. A., application engineer, Westinghouse Electric Corp., Baltimore, Md.
Vigour, H. E., unit supervisor, General Electric Co., Schenectady, N. Y.
Wells, H. J., electrical supervisor, Stone & Webster Engineering Corp., Boston, Mass.
Wier, A. J., member of technical staff, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

90 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grade of Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before June 25, 1955, or August 25, 1955, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Comach, S. I. (re-election), Dept. of Defence Production, Ottawa, Ont., Canada
Gardiner, W. C., Olin Mathieson Chemical Corp., Niagara Falls, N. Y.
Hoye, F. W., James L. Entwistle Co., Providence, R. I.
Ingraham, A. K., Pacific Gas & Elec. Co., San Francisco, Calif.
Mack, M. C., Westinghouse Elec. Corp., Baltimore, Md.
Pierce, J. F., University of Tennessee, Knoxville, Tenn.
Richardson, W. M., The Ramo-Wooldridge Corp. of Los Angeles, Washington, D. C.
Tashjian, D. R., Westinghouse Elec. Corp., Baltimore, Md.

8 to grade of Member

OF CURRENT INTEREST

New Radio Navigation System for Aircraft Provides Maximum Accuracy of Information

THE AVAILABILITY of a new and revolutionary radio navigation system, described as one of the most important advances in air navigation in recent years, has been announced by International Telephone and Telegraph Corporation.

Known as TACAN (tactical air navigation), the system is a powerful air navigation aid which provides the pilot with continuous information on the position of his aircraft, both distance and direction of flight, relative to a fixed ground station instantly, automatically, and with extreme accuracy. The equipment is small and compact (7 by 10 by 15 inches) and occupies only about 1,000 cubic inches of space, several times less than that occupied by previous air-borne units providing less navigational information.

Described by military and civil aviation officials as one of the most significant advances in air navigation in decades, the system is expected to have a far-reaching effect on the nation's navigation and air traffic control program. It was designed for the U. S. Navy by Federal Telecommunication Laboratories, Nutley, N. J., research division of International Telephone and Telegraph Corporation, and has been under development by the Laboratories since 1948. The new military air navigation aid has been accepted by the U. S. Air Force for interservice standardization and is being advanced by the Air Navigation Development Board (ANDB) as the basis for a common navigation system capable of serving all types of aircraft.

While TACAN is still a classified military system, the performance characteristics of the equipment have been declassified, and it is now possible to discuss what it does. The new aid, it was pointed out, represents a giant stride in the development of the "ultimate system" described in the recommendations of the Radio Technical Commission for Aeronautics (RTCA) Special Committee *SC-31*, which established the concept of a single and ultimate system of navigation suitable to all users of air space and geared to perform a variety of navigation and traffic control functions.

Tests have shown that TACAN has an azimuth or bearing accuracy to within 1 degree, probably the highest ever achieved by a bearing-giving system. Improved design features and the relative absence of site effects in TACAN account for its pinpoint accuracy. This, combined with its accuracy in distance of the order of 2/10 mile, makes it superior to ordinary radar accuracy.

Factors which led to the development of TACAN, according to ANDB's fact-finding committee, were the unavailability of any accurate radio navigation aid capable of operation aboard aircraft carriers and in military theaters where time-consuming installations and selection of favorable sites are ruled out.

To solve these problems, the Navy, in 1948, launched a study-development program at Federal Telecommunication Laboratories, which finally resulted in the TACAN system. This development was, in effect, a continuation of some basic technical investigations into azimuth and distance systems which they had previously conducted for the Air Force.

TACAN differs from other aids in that it is an integrated navigation system rather than a conglomeration of separate unrelated navigational aids, such as has been available to the aviation industry in the past.

This new concept and the concentration of research and development on a compact all-inclusive system such as TACAN results in:

1. Reduction of the frequency spectrum used to the minimum possible bandwidth necessary for the accuracy demanded, with considerable saving of the frequency spectrum.

2. Large savings in volume and weight of air-borne equipment by combining azimuth and distance functions into the same r-f channels and circuits, with corresponding reductions in the number of antennas, r-f cables, and components.

3. Maximum accuracy in direction and distance indications, so important to safety in aerial navigation of aircraft operating from ships, mobile units, and certain ground sites where former systems have been limited in performance because of damaging effects of surrounding physical characteristics, such as hills, masts, buildings, etc.

Large-scale production of the complete TACAN system for military use has already been started at Federal Telephone and Radio Company, manufacturing division of IT&T, and in addition, Stromberg-Carlson Company and Hoffman Radio Corporation are also manufacturing the air-borne equipment. IT&T will, in accordance with its general policy, grant licenses to others under its patents for the manufacture of this equipment for civilian use.

CHARTING AIRCRAFT POSITION (left) by use of IT&T's new tactical air navigation system. Navigation by TACAN (right) is accomplished by selecting a radio channel corresponding to a ground station and obtaining distance and direction in relation to it.

General view of the interior of the Union College field house

First Large 400-Cycle Fluorescent Lighting Is Installed in Union College Field House

A NEW EFFICIENT general lighting system, seen as a forerunner of many large industrial, commercial, and institutional lighting installations, has been installed in Union College's nearly completed Alumni Memorial Field House in Schenectady, N. Y. The system is the first application of high-frequency fluorescent lamp operation for the general lighting of a large area.

Designed and developed by the General Electric Company, the system calls for the operation of 490 8-foot-long slimline fluorescent lamps on 400-cycle power. Increasing the frequency to 400 from the standard 60 cycles is accomplished by means of two 30-kw rotating-type frequency converters.

Chief benefit of the new system is that it represents the most economical method yet devised for obtaining higher levels of light in high-bay areas, according to J. H. Campbell, General Electric illuminating engineer who conceived and developed the technique.

The system cost approximately 10 per cent less to install than an incandescent-mercury lighting system originally considered for the field house. In addition, the 400-cycle system offers an estimated 50-per-cent savings in annual operation and maintenance cost while producing 20 per cent higher levels of comfortable light.

The problem at the Union College Field House was to illuminate 44,000 square feet of floor area to a maintained light level of 45 foot-candles. As the area is to be used for basketball games, and as a practice field for baseball, football, track, and lacrosse, fluorescent lighting was considered desirable in order to avoid the relatively higher brightness inherent in incandescent-mercury systems. High-frequency operation made fluorescent lighting practicable for this installation because each fixture weighs 110 pounds less than for a comparable 60-cycle system, and because wiring costs are much lower.

The level of illumination is said to be the highest for any field house. It is more than twice the amount of light provided by typical field-house installations.

High-frequency operation allows slimline fluorescent lamps to produce levels of light from 20 to 50 per cent higher than the same lamps operated on the conventional 60-cycle power. Lamps at the Union College installation are operated at 22 per cent over their 60-cycle rating in watts.

Installation of rotary frequency converters permits use of ballasts that are simpler, more efficient, and about one fifth the size and weight of regular ballasts. The converters themselves are comparatively low in cost and reliable in service.

The fixtures, designed by C. J. Allen, the company's school and indoor sports lighting specialist, were made by Curtis Lighting, Inc., Chicago, Ill. Largest fixtures ever used for high-bay lighting, they are 8 feet square, but weigh considerably less than would comparable fixtures in conventional lighting installations. Each fixture contains 14 slimline lamps.

Lighting fixtures are mounted at heights varying from 60 feet in the center to 34 feet on the sides. Each lamp produces 6,000 lumens. The entire lighting job produces a total of about 3,000,000 lumens.

The lighting layout is so arranged that each of the two rotary converters operates the lamps to allow for approximately equal distribution of light. A simplified wiring system reduces the number of circuits from 84, for the lighting method originally considered, to 14 for the high-frequency design.

The primary power source for the system is 208 volts, 3 phase, 60 cycles, and the secondary is 600 volts, 3 phase, 400 cycles, connected to be 300 volts to ground. Since 400 cycles as well as starting voltage is distributed, it is possible to use a simple series capacitor and series choke for ballast on alternate lamps. The split-phase circuit produces unity power factor to obtain maximum utilization of the converters.

Howard D. Kurt, General Electric electrical engineer, made the wiring layout for the installation, and also helped design the power system.

Although somewhat similar 400-cycle systems have been developed for airplane and bus lighting, this is the first building interior to be lighted by means of 400-cycle power.

One of the earliest General Electric high-frequency lighting projects was that involving 360-cycle lighting, and employing a magnetic frequency multiplier. This installation was made in 1951 at the Plant Industry Station of the U. S. Department of Agriculture in Beltsville, Md., where plants are grown entirely under artifical light.

Although pioneer high-frequency lighting installations have been confined to specialized applications, the large-scale Union College Memorial Field House project is expected to cause architects, builders, and users seriously to consider this new tool for

HEART of the high-frequency fluorescent lighting system in the field house are two 30-kw rotating frequency converters, one of which is shown above. Electric components of the units include a 45-hp 208-volt motor, 30-kw 600-volt 400-cycle generator, direct-coupled exciter, 208-volt contactor with thermal overload relays, regulator, potential transformer, input and output fuse disconnect switches, and a voltmeter.

illumination in planning future lighting jobs.

For a discussion of "Frequency and Fluorescent Lamps" see the article by D. E. Spencer in *Electrical Engineering* for December 1953, pages 1066–70.

Museum Is Dedicated at Ford Instrument Company

Ford Instrument Company, Long Island City, N. Y., a division of The Sperry Corporation, observed its 40th anniversary recently by dedicating a permanent company museum illustrating progress in the science of weapons control since 1915.

Chief exhibits in the museum include the world's first automatic tracking bombsight, first time-of-flight clock, first antiaircraft computer and gun director, and first automatic computer and plotter for artillery battery direction. Also in the museum is what is probably the world's first automatic "brain" for controlling gunfire—the Range Keeper Mark I.

In dedicating the museum, Raymond Jahn, president and general manager, said: "This room is a memorial to Hannibal C. Ford, our founder. Mr. Ford revolutionized naval warfare by developing and building the first computer to solve automatically the problem of range between two moving ships. From his historic Range Keeper Mark I grew all the complex fire-control mechanisms of our present-day naval vessels. . . ."

Holt McAloney, director of public relations, in reviewing a brief history, said: "The Mark XIX was a triumph . . . . In 1924 when the great debate as to whether an airplane could sink a battleship was settled by General Billy Mitchell's boys sinking two old German battleships, the Navy called on Mr. Ford. 'Build us a gun director that can track a moving airplane from the rolling deck of a ship, and aim the guns to shoot it down,' they asked. The problem seemed almost unsurmountable. But within 18 months the Mark XIX was designed and two of them were made and installed on the U.S.S. *Maryland*. I am told that in the spring of 1926 the first firing of the guns directed by this great instrument scored six successive hits on towed targets."

Also speaking at the ceremony, Henry McKenney, chief engineer, told of some of the problems of designing instruments to stand up under combat conditions. A. E. Edwards, vice-president for manufacture, told of the many special skills and precision machining which were used in manufacturing the precision instruments the company has been making for 4 decades.

New Long-Distance Telephone Begins Operation in St. Louis

A new long-distance telephone center, scheduled to become the hub of a dialing network for the nation, was placed in service on April 17 in St. Louis, Mo.

The intricate equipment, a joint undertaking of the Long Lines Department of American Telephone and Telegraph Company and Southwestern Bell Telephone Company, was cut into operation after extensive testing of circuits leading to the center from all parts of the United States.

The installation eventually will serve as the national center for the Bell System's long-distance dialing network. It also will function as one of nine regional switching centers. The others are located in Atlanta, Ga.; Chicago, Ill.; Dallas, Tex.; Denver, Colo.; Los Angeles, Calif.; Pittsburgh, Pa.; Sacramento, Calif.; and White Plains, N. Y.

Long Lines, the long-distance operating unit of American Telephone and Telegraph, said the addition of the St. Louis center brings the number of cities and towns on the distant-dialing network to 3,600.

The automatic switching mechanism that made intercity dialing possible was first installed 12 years ago in Philadelphia, Pa. Since then it has been put into operation in 32 cities over the nation, including St. Louis.

Today telephone operators are dialing more than half of all long-distance calls directly to the distant telephone without going through intermediate switchboards. Eventually they will be able to dial almost any telephone in the United States and Canada directly.

Westinghouse Develops Voice for Use in Self-Service Elevators

To bring the power of speech to the electronic brains in charge of operatorless elevators, Westinghouse engineers have developed a "voice" to communicate recorded messages to elevator passengers. This voice is intended to bring information and assurance to passengers who are not familiar with the elevator system or the building that it serves.

A demonstration of the new equipment in New York, N. Y., recently showed how messages stored on a magnetic tape in a remote location are reproduced by loudspeakers concealed within the walls of the elevator car.

As passengers enter, the recorded voice announces "This car up" or "This car down." Later, if the first passenger to enter has neglected to select his floor by pressing a floor button, the voice admonishes him to "Press your floor button, please." Should a passenger attempt to delay the car by restraining the doors, the recorded voice again intervenes to speed service by courteously requesting, "Release the door, please." The voice is so completely in touch with traffic conditions that it may request, "Step to the back of the car, please," if passengers are crowding near the doors.

When in use in operatorless elevator systems in department stores, a special adaptation of the communication system may announce the floor number of the next stop and then summarize the merchandise to be found on that floor.

The system demonstrated includes magnetic-tape reproduction equipment installed in the elevator machine room, loudspeakers within each car, and interconnecting cables. The system is fully automatic and, without supervision, is capable of reproducing whatever message is called for by traffic conditions.

Yale Chemists Study Atomic Garbage Disposal

One of the more perplexing problems which the modern scientist has brought upon himself is the disposal of "atomic garbage," the leftovers of any atomic fission experiment. Research currently underway in Yale University's Chemical Engineering Department may help solve the riddle of what to do with something indestructible and dangerous that nobody wants.

These atomic wastes take many forms, either liquid or solid, metallic or chemical. Because of radiation danger, extreme care has to be taken to dispose of the wastes which currently are either buried deep in the ground, dumped into the ocean, or stored until the radiation dies out. Radioactive waste materials will increase as soon as atomic power plants, already on the drawing boards, are perfected. Each city will then have to cope with a new garbage problem.

Yale chemical engineers are working to utilize these wastes. Under an Atomic Energy Commission contract, these engineers, headed by R. H. Bretton, associate professor of chemical engineering, are experimenting with the effects of gamma radiation produced by the "atomic garbage."

Experiments thus far have been conducted on ethylene, acetylene, and vinyl-chloride, all gases. "These materials were chosen," Professor Bretton explained, "because they were known to undergo a chain-type reaction in polymerization." (Polymerization is the change of one chemical compound into another compound having the same elements in the same proportion, but having a higher molecular weight and different physical properties.) By using these three gases the Yale engineers can determine quickly and conclusively the effects of gamma radiation on various chemical compounds.

To study the effects of this radiation, the chemicals and gases under test are placed in test tubes in contact with radiation sources,

then subjected to gamma radiation as well as to pressures and high voltages.

Of interest thus far, Professor Bretton pointed out, is the fact that prolonged gamma radiation polymerizes both ethylene and acetylene to a waxy powder. There is considerable industrial interest in the manufacture of polymerized ethylene, and the most widely known form of this material is in the transparent rubbery bags used for packing fruits and vegetables.

Present methods of manufacturing polyethylene require high temperature and high pressure, but if some gamma radiation could be used to shorten or simplify the manufacturing process, this atomic waste material would be of use to industry.

Experiments with the other two materials, acetylene and vinyl-chloride, are less direct in their application, but they do prove that gamma radiation, coupled with low or high pressures and high voltage, can produce chemical changes in matter which are otherwise difficult to accomplish.

U. S. to Build Atomic Reactor for World Conference at Geneva

Lewis L. Strauss, chairman of the Atomic Energy Commission (AEC), has announced that the United States will build an operating research reactor at Geneva, Switzerland, for demonstration at the United Nations International Conference, August 8–20, 1955.

The project, expected to be a major exhibit feature of the conference, has been made possible through the co-operation of the Government of Switzerland and the Secretary General of the United Nations.

"We are confident that the operation of a large research reactor at Geneva during the conference will add immeasurably to the interest and usefulness of this important meeting," Mr. Strauss said. "This instrument will use the type of fuel that other nations can draw from the 100 kilograms of Uranium 235 the United States has made available for research reactors in other countries as a major step in President Eisenhower's atoms-for-peace program."

The exhibit would enable visiting scientists and technicians to observe a reactor which provides excellent facilities for a variety of cross-section measurements, experiments with neutrons and gamma rays, including shielding studies and production of radioisotopes.

Qualified scientists and technicians will be allowed to operate the machine, using the controls to start, maintain, and stop a nuclear chain reaction within the reactor. During these experiments, known as criticality tests, the familiar blue glow of the irradiated fuel elements will be visible in the water.

The reactor will be of the "swimming pool" type successfully operated at the AEC's Oak Ridge National Laboratory for several years. Research reactors of this type are now being constructed at the Pennsylvania State and Michigan Universities. The name comes from the fact that the reactor is immersed in a pool of water which affords an effective safety shield against radiation.

The project for the Geneva conference will be carried out by Oak Ridge National Laboratory, which is operated for the AEC by the Carbide and Carbon Chemicals Company, and will be under the general supervision of Dr. G. L. Weil, technical director of United States' participation in the Geneva conference.

The fuel will be fuel-grade uranium enriched in isotope 235 to about 20 per cent. About 5 kilograms of Uranium 235 will be required. The reactor will be tested at Oak Ridge and then dismantled and shipped to Geneva. The reactor and its fuel would be at all times under the control and custody of the AEC.

It will be housed in a temporary prefabricated metal building designed especially to enable the delegates and visitors at Geneva to see the reactor in operation.

The "swimming pool" feature will be a tank 10 feet in diameter and 20 feet deep, in which the entire reactor is immersed. Specially purified water is used for the shielding. Health and safety control will be built into the reactor.

A small platform will be built on top of the reactor, from which a lecturer can direct demonstrations and explain the operation of the machine. The housing structure will be designed to accommodate a constant flow of visitors observing the operation of the reactor.

The swimming pool reactor, which is estimated to cost about $350,000, will be part of the technical exhibit being planned by the United States at Geneva.

12-Channel Telephone System Designed for Use by Field Services

A new portable G. I. telephone system, which can handle three times as many conversations over a single cable as comparable Korea and World War II systems, has been developed for the U.S. Army Signal Corps by Bell Telephone Laboratories.

Basic equipment for the new telephone system is contained in units about the size of large suitcases which can be handled by only one or two men. These units are designed so they can be stacked one on another. The "carrier" principle used for the new system now allows 12 conversations to share the same cable by using a different frequency for each.

The new system, providing for 12 simultaneous conversations, can be used for distances up to 200 miles. Another, a 4-channel system, can be used for four simultaneous conversations at distances up to 100 miles. Several of these wire systems linked together can form a communication system of about 1,000 miles. They may also be operated in conjunction with a G. I. radio-relay system developed at Bell Laboratories.

Recently developed miniaturized parts can be credited with the sharp reduction in size and weight of the new equipment. The earlier 4-channel unit, for example, weighed 475 pounds and occupied 20 cubic feet of space. Complete with its power supply, the new 4-channel terminal weighs 178 pounds and occupies only $5^1/_2$ cubic feet of space. The cable used for the systems can be strung on poles, laid on the ground, or buried.

New types of repeaters have also been designed to be used at intervals in order to restore the level of the transmitted signals and extend the range of the systems.

Important new features facilitate testing

Future Meetings of Other Societies

National Society of Professional Engineers, Annual Meeting. June 2–4, 1955, Bellevue-Stratford Hotel, Philadelphia, Pa.

American Gear Manufacturers Association, Annual Meeting. June 5–8, 1955, The Homestead, Hot Springs, Va.

Columbia University, Conference on Industrial Research. June 6–10, 1955, Arden House, Harriman, N. Y.

American Welding Society, Spring Meeting and Welding Show. June 7–10, 1955, Hotel Muehlebach and Kansas City Auditorium, Kansas City, Mo.

International Organization for Standardization, Meeting as guests of Sveriges Standardiseringkommission. June 8–18, 1955, Stockholm, Sweden

Special Libraries Association, Annual Convention. June 12–17, 1955, Hotel Statler, Detroit, Mich.

American Water Works Association, Annual Conference. June 12–17, 1955, Chicago, Ill.

National Association of Power Engineers, Annual Convention. June 13–17, 1955, Hotel Waldorf-Astoria, New York, N. Y.

Edison Electric Institute, Annual Convention. June 13–16, 1955, Philharmonic Auditorium, Los Angeles, Calif.

The American Society of Mechanical Engineers, Semiannual Meeting. June 19–23, 1955, Statler Hotel, Boston, Mass.

American Society for Engineering Education, Annual Meeting. June 20–24, 1955, Pennsylvania State University, University Park, Pa.

Institute of the Aeronautical Sciences, International Conference with Royal Aeronautical Society of Great Britain. June 21–24, 1955, I.A.S. Building, Los Angeles, Calif.

American Society for Testing Materials, Annual Meeting. June 27–July 1, 1955, Chalfont-Haddon Hall, Atlantic City, N. J.

American Nuclear Society. June 27–29, 1955, Pennsylvania State University, University Park, Pa.

International Electrotechnical Commission, Meeting as guests of the British Standards Institution. June 28–July 9, 1955, London, England

National Skilled Manpower Training Conference, sponsored by the Virginia Apprenticeship Council with the assistance of the U. S. Department of Labor's Bureau of Apprenticeship. July 5–8, 1955, Chamberlin Hotel, Old Point Comfort, Va.

Symposium on Electronics and Automatic Production, jointly sponsored by Stanford Research Institute and the National Industrial Conference Board. August 22–23, 1955, San Francisco, Calif.

Western Electronic Show and Convention. August 24–26, 1955, Civic Auditorium, San Francisco, Calif.

Instrument Society of America, Conference, "Instrumentation Paces Automation." September 12–16, 1955, Shrine Auditorium, Los Angeles, Calif.

Association for Computing Machinery, Annual Meeting. September 14–16, 1955, University of Pennsylvania, Philadelphia, Pa.

Illuminating Engineering Society, National Technical Conference. September 12–16, 1955, Statler Hotel, Cleveland, Ohio

Radio-Electronics-Television Manufacturers Association, Automation Symposium. September 26–27, 1955, Irvine Auditorium, University of Pennsylvania, Philadelphia, Pa.

Atomic Industrial Forum, Trade Fair and Fall Meeting. September 26–30, 1955, Sheraton-Park Hotel, Washington, D. C.

Société Belge des Ingenieurs des Telecommunications et d'Électronique, International Analogy Computation Meeting. September 27–October 1, 1955, Brussels, Belgium

12-CHANNEL TELEPHONE system which was designed for field service by Bell Telephone Laboratories. The "stackable" units are part of a system which can carry 12 conversations simultaneously and can be used for distances up to 200 miles.

and maintenance while all regular channels are in service. A portable test set provided with the 12-channel system contains a transistor oscillator, one of the first applications of the Bell Laboratories transistor in quantity-produced military equipment.

Field equipment designed by the Laboratories for the Army is tested for its ability to withstand desert heat and arctic cold. It is subjected to vibration, bounce, and shock tests, exposed to 100-per-cent humidity, and to wind and rain.

Ultrasonic Soldering Iron Permits Fluxless Soldering

The development of the Glennite ultrasonic soldering iron makes possible the joining of aluminum, magnesium, and their alloys without flux or where corrosive fluxes must be avoided. It is particularly useful for soldering metals that form refractory oxides, without tinning or special surface pretreatment. It can be used also for filling voids in aluminum or magnesium castings. Its light weight and portability enables an operator to solder such items as pipes, gutters, and waveguides, which are not normally available for bench assembly.

These instruments include the soldering iron, having either a gas or electrically heated tip, and a power generator for driving the soldering iron. The soldering tip is attached to a transducer composed of a piezoelectric resonator and a special stainless-steel tapered horn. This horn is a mechanical transformer which provides a substantial increase in vibration amplitude and, because of its low thermal conductivity, isolates the hot soldering tip from the piezoelectric element and the handle. The transducer vibrates mechanically at approximately 22 kc, which is relatively silent during operation. The gas-fired unit is mounted directly on a torch with a small tank which serves the dual purpose of a handle and a container of compressed propane gas, thus leaving one hand free to feed the solder onto the work. The electrically heated unit has a 65-watt heating element inside the tip and is held with a pistol-grip handle. This unit is recommended for light work since the high thermal conductivity of aluminum, except for small pieces, would cool the tip too rapidly. The gas-fired unit can be used on large pieces and can also be adapted to a torch with a hose connection to standard gas mains.

The efficiency of the piezoelectric resonator coupled to the mechanical transformer provides sufficient drive for rapidly soldering reasonably large pieces of aluminum without flux. Only 35 watts of electric energy is needed to drive the soldering tip to provide sufficient agitation of the molten solder to remove oxide films allowing the solder to wet and adhere to the parent metal surface. This high efficiency has made it possible to reduce the size, weight, and cost of the soldering unit and the generator materially. The soldering iron transducer assembly weighs less than $1^1/_2$ pounds, and the generator weighs 15 pounds. The unit is entirely portable.

Soldering tips for the gas-heated iron are solid 3/8-inch copper-alloy stock and may be shaped by filing to fit the particular needs of the job. New tips can be replaced only by silver brazing to the stainless-steel horn. The electrically heated tips are hollow and only light filing is recommended. In use the iron is placed on the work and, when the material is heated sufficiently to melt the solder, the transducer is energized and the iron can be used to flow the molten solder over the surface. In soldering, a 90-per-cent tin–10-per-cent zinc solder is recommended for aluminum and magnesium and their alloys.

The power supply is housed in a metal case 9 by 9 by 6 inches and is provided with a carry handle for easy transportation. The unit has a gain control with an off-on power switch, and a fine frequency-tuning control. A foot switch is provided for off-on control of the generator output. In addition, a panel meter is mounted to indicate relative power and tuning.

New-Type Battery Used in Holloman Rocket-Sled Test

A small, but powerful, new type of storage battery was used by the U. S. Air Force in verifying that Lt. Col. John P. Stapp is the fastest living human on earth. The Yardney Electric Corporation, New York, N. Y., learned from the USAF that 19 Silvercels were carried aboard the rocket sled in which the airman skidded to a halt in $1^1/_2$ seconds after attaining a speed of 632 mph at Holloman Air Development Center, New Mexico test site.

The 5-ampere-hour electric units were used to power telemetering equipment monitoring the test. The Silvercels used weighed little more than 4 ounces each, and were no larger than a pack of cigarettes. Great importance was attached to the size and weight of equipment used aboard the sled because of the shock induced by the severe deceleration. The Yardney units withstood a force of 30 to 35 *g*'s (30 to 35 times their own weight) without damage.

Flexible Infrared Oven Walls Lessen Paint-Drying Time of Autos

Time savings of $7^1/_2$ hours in the drying of automotive bodies have resulted from the installation of a new drying oven at Summerfield Chevrolet Company, Flint, Mich. Under concentrated far-infrared radiation (4 to 9 microns) provided by Chromalox electric radiant heaters, freshly painted vehicles are now dried in only 30 minutes, an operation that formerly took as long as 8 hours in dustfree atmosphere.

This saving in time has increased the productive capacity of the paint shop. It has also freed valuable space, formerly required for storing vehicles during the air-drying and curing operations, for other types of collision and mechanical repairs.

Painting of car and truck bodies in the shop is accomplished by a drive-through series of operations, similar to the assembly lines in nearby automobile factories.

Following application of paint in the shop spray booth, the vehicle is moved directly down the line to the drying oven. Once inside, batteries of radiant heaters train intense drying rays evenly on all parts of the painted surface. Thirty minutes later, the vehicle is moved onto the wash rack for a cold-water spray which hardens the dried paint.

Key factor in this accelerated painting service is the type of heating unit in the drying oven. Sixty-four 1,500-watt Chromalox electric radiant heaters are set in tiers in the panels of both oven walls.

Automatic controls regulate the output of the heating elements and the inclination of the panels of the oven walls. Each of the two oven walls has three panels: vertical bottom, inclined center, and top horizontal. For passenger cars and small panel trucks, the inclined center and top horizontal panels can be lowered into a tunnel shape for drying coverage of the entire vehicle. The oven walls are adjustable to vertical upright positions for the larger trucks and trailers. Each wall can be regulated independently of the other. Zone control of the heaters in each panel permits spot drying of vehicles, with only one heating zone in use.

A nonoxidizing (Alzak) aluminum reflector is fitted into the parabolic housing of each heater. Heat from the element is focused in essentially parallel rays by the highly polished reflector. The result is a uniform band of heat, which eliminates hot spots on the vehicle surface.

Electronicam System Offers Advantages to Broadcasters

The "Electronicam"* television film system, a product of Allen B. Du Mont Laboratories, Inc., New York, N. Y., gives the broadcaster a high-definition motion picture film of a program in color or black and white with quality equal to the best motion picture film, and provides a live broadcast picture with quality equal to that of live telecasting. A feature of the system is the speed with which it operates; scenes may be filmed in the same time it takes to view them. The new development offers tremendous and far-

* Registered trade-mark

SWITCHING AND CONTROL PANEL (left) permits studio engineers to edit and develop the editing master, used with Electronicam system. Special effects such as laps, fades, dissolves, wipes, and superimpositions, which are electronically created, appear on the editing master. High-quality film footage (right) may be rapidly edited into a final finished product for distribution by means of the editing device shown. The editor may quickly decide by checking the editing master which camera's footage was chosen by the director during shooting.

reaching advantages to the television, television film, motion picture, and advertising industries, as well as to the military services, general industry, science, medicine, education, and many other fields.

The system operates in the following manner: An image-orthicon camera head and a film camera are mounted side by side on the same base and have a common lens system. Light passing through the common lens is split into two parts: one to the film, and one to the pickup tube of the unit's television section. A focus control located on the back of the television camera section controls the focus for the common lens system.

In addition to the high-quality film being shot an "editing master" is produced by the Electronicam system in the form of a teletranscription film or kinescope, which serves as a guide for assembly of the final high-quality film product. The editing master immediately shows which camera's footages was chosen by the director during the shooting, and it records the wipes, fades, dissolves, scene shifts, and other effects which were ordered by the director and which appeared on the monitor.

The speed with which the high-quality films can be made, processed, and shipped to television stations throughout the country will provide many benefits. Programs can be made and distributed in advance for local showing at preset times in either monochrome or color. The speed with which the film can be shot will greatly cut down production costs and make programs more attractive to sponsors.

The system's advantages to the motion picture industry are also of major importance. James L. Caddigan, director of programming and production for the Du Mont Television Network, said that under currently used methods, movie directors must wait for processing to see the rushes or results of a day's movie shooting. If the films are not suitable, entire scenes must be reshot. Although the director may look through a movie camera viewfinder before the picture is shot, once the cameras start to roll, he has no control over the picture except to stop it and start over. With Electronicam the television camera section sends a television picture of what the camera "sees" to a monitor picture screen so that all those in charge of the shooting have an instantaneous view of exactly what the film camera is shooting at all times.

Scatter Radio Propagation Experiments Are Initiated

A long-range testing program on a new type of communication link was launched at Syracuse University, Syracuse, N.Y., March 15, 1955, when a receiving station built on the summit of a university-owned ski hill was put into operation.

Depending on its practicability, this new link may play a vital role in both defensive and offensive military operations. Broadcasts transmitted over it would be harder to jam, more difficult to listen in on, and less subject to noise interference than those sent over conventional radio links.

This link may also open up to the military for the first time new long-distance communication paths, free of relay towers. At present, FM and pulse-type broadcasts cannot be received beyond the line of sight without the assistance of such towers.

For the military, extended clear communication paths would be a great asset, since in the scope of military activity, the building of relay towers is often made difficult by inaccessible terrain and stringent time limitations. Moreover, not having to depend on relay towers would greatly increase the flexibility of military communications operations.

Experimentation on this link is being made possible by the U. S. Air Force's Research Center at Cambridge, Mass. A contract for this research work, extending to January 31, 1956, has been awarded to Syracuse University through its Research Institute.

Daily, signals emanating from an Air-Force-operated transmitting station at Lexington, Mass., are being sent to Syracuse. AM, FM, and pulse-type modulations are being used. The intelligence, either voice or Teletype, is beamed from Lexington at a high carrier frequency of 915 mc. This high-frequency signal is scattered beyond the line of sight from the ionosphere or troposphere, reflecting layers some 50 to 75 miles above the earth. The dispersion of the signal is called scatter propagation. As a result of this scattering some of the signal descends earthward where it can be picked up by a receiver.

All signals received at Syracuse are indicated by graph lines on recording instruments. The men responsible for interpreting these recorded data are Drs. Samuel Seely and Stanford Goldman, professors of electrical engineering. At present there are such variations in the intensity of reception that more needs to be known about the operability and reliability of this communications link.

"We hope to determine through these tests," explained Dr. Seely, "which type of modulation, if any, is best suited to this particular link. To help us do this we will try to arrive at specific correlations between reception variations and the time of day, weather, and seasons of the year. Little is known about the underlying basis for scatter propagation. We hope eventually to determine a theoretical model accounting for this scatter phenomenon."

This is the first time that tests of this kind have been conducted over a land distance of 250 miles. Tests at this distance, however, have been made over water from Lexington to Fort Monmouth, N. J.

MIT Receives Grants From General Dynamics

Three grants to the Massachusetts Institute of Technology (MIT), Cambridge, Mass., from General Dynamics Corporation were announced recently by John Jay Hopkins, chairman and president of the corporation.

Mr. Hopkins said the company has given MIT $5,000 to be used toward the construction of the Karl Taylor Compton Laboratories which will be built in honor of the in-

stitution's late president. The laboratories will house the programs of research now under way at MIT in the Laboratory for Nuclear Science, in the Research Laboratory of Electronics, and other research projects now being carried on at the institution.

In addition to the laboratory grant, General Dynamics has established two 1-year fellowships at MIT, one in nuclear engineering, the other in electronics. Both have been established on an annual basis. The fellowships will be instituted later this year. Each carries a stipend of up to $4,000, part of which is an unrestricted grant to MIT.

Iconumerator Counts Up to Million Objects in a Second

A new electronic device which can count up to 1,000,000 objects of varying shapes and sizes in 1 second has been developed by the Instrument Division of Allen B. Du Mont Laboratories, Inc.

The device, called the Iconumerator, is expected to be of major importance in many fields of science and industry and wherever rapid counting of objects may be desirable. A few of the hundreds of the uses to which the device, or modifications of it, may be put are: the counting of blood cells in mass blood tests; the mass counting of assorted machine parts such as nuts and bolts; the counting of stars appearing on astronomical photos; and the counting of impurities in raw materials such as powdered chemicals or foodstuffs such as flour. The Iconumerator was designed and built under the supervision of Du Mont engineers Carl Berkley and H. P. Mansberg.

THE ICONUMERATOR, a new electronic device which, in 1 second, can count up to 1,000,000 objects of varying shapes and sizes. In operating the unit, the objects to be counted are placed in a "counting house" compartment at the lower front of the device. A picture of the objects being counted appears on the screen (right center) and the number of objects appears on the six columns of the electric tote board at the top of the unit within 1 second.

The action of the Iconumerator may be compared to a human using his eyes, brain, and a pencil and paper or other recording implements to count objects and record them. The unit, however, works at superhuman speed. The device "sees" objects placed in a special compartment at the front of the unit, counts the objects one-by-one, remembers what it has counted, and transfers the results to an electric tote board, where they appear as lighted numbers. When desired the unit may be attached to an electric printing machine which provides the answers in printed form on a sheet of paper in much the same fashion as a person taking down answers on a typewriter.

The Iconumerator employs a principle known to electronic engineers as flying-spot scanning as one of its chief features. This process employs a cathode-ray tube which has on its screen a pattern of light composed of 1,000 individual lines, which is almost twice the resolution found in a television picture. When objects to be counted are placed within the unit's "counting house" compartment, light from the tube shines on them and scans line by line. This light is reflected from or transmitted by the objects, line by line, and passed through a lens system analogous to the human eye. The light, focused by the lenses, falls on a photoelectric cell analogous to the retina of the eye. This photocell, under the action of the light, generates an electric signal proportional to the light falling upon it. The signal is then passed to special circuits which correct any deficiencies in the lens and the signal.

The corrected information is then fed to the "brain" or the system, which consists of a memory section to store information, and a computer, which, together, determine how many objects there are and indicate the figure accurately in 1 second. In the Iconumerator illustrated, the range of the display unit being used is 999,999 counts. Other units may be selected with greater or lesser ranges, as convenient, depending on the resolution of the system being used. This resolution depends on the excellence of the scanning tube, the number of lines used in scanning, the precision of the circuitry, and similar design factors.

The Iconumerator is not to be confused with an electronic brain or computer which solves mathematical problems. It merely counts what it "sees" but at far greater speeds than are possible by the human eye–brain combination, and with perfect accuracy.

For example, it can count ten pennies or 1,000 grains of salt in a second if these units are arranged so that they are visible for counting. If a number of pennies are piled upon each other so that some are completely hidden, the device cannot count the hidden pennies anymore than can the human eye. The unit will also count irregularly shaped objects correctly. For example, a penny and a doughnut placed side by side are counted as two objects. Similarly, if a penny is placed in the "hole" of a doughnut and placed in the counting compartment the unit will count two objects. A disk perforated with many holes, and similar irregularly shaped articles, are counted as individual objects. Even objects which overlap may be counted as individual units.

The basic circuitry can also be modified so that ten pennies and 1,000 grains of salt may be scanned at the same time and both groups may be counted together or separately.

In flood areas, cultures of samples of drinking water taken from over wide areas may be quickly counted for numbers of bacteria. Throughout the nation tests are made daily to safeguard the milk supply against contamination. These tests require the laborious inspection of hundreds of thousands of "milk plates." This counting operation may be enormously accelerated by the use of the Iconumerator.

By changing the optics of the instrument, particles in the air which might be hazardous to health or safety, as, for example, excess of coal dust in mines, chaff or flour in flour mills, or particles of paint or metal shavings, may be quickly spotted so that steps to eliminate the hazards may be taken.

Since the Iconumerator can detect particles of different sizes, the techniques employed offer promise in devices for mass detection of cancer. As cancerous cells are sometimes of different size from healthy cells surrounding them, samples of tissue obtained from a biopsy could be placed in the counting compartment after suitable preparation so that the unit could quickly detect the presence of malignant bodies and determine their number.

Honeywell Tape Control Will Automatize Precision Boring

The punched-tape principle of automatic operation has been applied to a precision boring machine used in the production of instrument gear trains.

A system worked out by Minneapolis-Honeywell Regulator Company includes a standard 4-spindle Excello precision boring machine modified with built-in electronic controls and circuitry and a tape "reader" housed in a specially built control cabinet. It is said that this represents the first application of tape-controlled principles to a precision boring machine.

Hold co-ordinates and feed instructions are punched on the tape by a perforating machine similar to a typewriter. Electronic signals from the tape regulate the linear travel of the boring machine's hydraulic cross slide and the rotary motion of a specially designed holding fixture mounted on the cross slide. Tape preparation requires approximately 5 minutes per hold and complete changeover from one part to another can be accomplished in about 30 minutes.

To set up automatic operation, the proper adapter ring is attached to the rotary fixture, cutting tools are mounted in the four spindles, and the punched tape is placed in the reader of the control circuit. After inserting a blank piece in the fixture, the operator merely presses a button to initiate the automatic tape-controlled cycle. After the ma-

chine has "read" the complete strip of tape, it automatically stops to permit removal of the finished part.

Designed for boring shaft holes in gear plates in which the center-to-center hold tolerances must be tight to prevent binding or backlash, the machine is adaptable to a variety of hold patterns and sizes.

Different piece parts can be handled merely by changing the adapter ring and inserting the appropriate tape. Where a small number of special plates is needed, the machine can be manually operated by adjusting ten knobs to control linear travel of the cross slide and rotary motion of the holding fixture. Manual control knobs are located in the control cabinet.

In either manual or tape-controlled operation, co-ordinate information is fed to the machine in increments of 0.0001 inch over the 8-inch linear range and 0.01 degree over the 360-degree rotary range. Accuracy is better than ±0.0005 inch.

Blade-Tip Lamp for Helicopters Withstands Forces up to 1,000 g

A new aircraft lamp that can withstand centrifugal forces up to 1,000 times the force of gravity has been developed by the Lamp Division of the Westinghouse Electric Corporation. Designed for use in helicopter blade tips, the new lamp is a joint development of Westinghouse and the Kaman Aircraft Corporation.

Helicopters have unusual maneuvering characteristics and therefore require special identifying lights to distinguish them from other types of aircraft. The Kaman Aircraft Corporation has been working with the U. S. Navy Bureau of Aeronautics in developing a distinctive lighting system that will not only enable other aircraft to recognize helicopters in night flight, but will also make possible helicopter night formation flying.

Biggest problem in the development was in making a lamp with a reasonable "life-span" under the high centrifugal forces existing at the blade tip. These forces can exceed 700 *g* on present helicopters, and reach 1,000 *g* under certain speed conditions. The lamp developed will withstand 1,000 *g*, each part of the lamp being subjected to a force 1,000 times its normal weight.

BLADE-TIP LAMP has two tightly coiled filament windings operated in series from a 12-volt power supply. Four heavy filament supports serve as lead-in wires, and are imbedded in the glass mount.

In order to provide the light intensity required, the lamp has two tightly coiled filaments in series. The lamp itself produces about 35 candlepower, but reflectors in the blade tips increase the effective light output approximately nine times.

A clear plastic housing in the blade tip encloses the lamp, and is designed to follow the blade contour as closely as possible so as not to affect the aerodynamic blade design. The lamp operates at 12 volts, and is supplied power from the helicopter's 28-volt electric system through resistance cable inside the blade that "drops" the voltage to the required level. A system of silver slip rings and brushes at the blade hub transfers the electric power from the fuselage to the blades.

Experimental work has been done in automatically switching on and off green and red lights on the blade tips so they create a green half-circle on the right side of the helicopter and a red arc on the left side. This color system makes any change in the plane's flight path readily discernible to pilots of other helicopters in formation, or to other approaching aircraft. A helicopter can back up and fly sideways, so it is vital to air safety that its movements be correctly interpreted.

Helicopters equipped with blade-tip lights are easily identified as far away as 5 miles, even against a background of city lights. Helicopters that use lights on the blades will continue to have green and red lights on the fuselage to identify the right and left sides of the plane.

HELICOPTER with its rotor tips lighted up by new aircraft lamps traces an unusual pattern of arcs in this time exposure. Heavy traces of light at bottom resulted from plane's hovering before starting ascent. Photographer used flash bulb to "freeze" helicopter midway in its climb.

Surface-Barrier Transistor Makes Small Computer Possible

A new concept of linking transistors in a miniature computer, called the TRANSAC for TRANSistor Automatic Computer, has been developed in the Research and Engineering Laboratories of the Philco Corporation.

Known as the Philco Direct Coupled Transistor Circuit, the invention presages mass production of transistorized computers capable of calculations at phenomenal speeds, and is a long step toward development of a "universal computer," a major objective of scientists in this field. For example, a digital computer using this transistor circuit could perform 600,000 additions or subtractions a second. Such a computer would operate approximately ten times as fast, and its size, weight, and cost would be about one third that of any previously announced transistorized computer, according to L. J. Woods, Philco vice-president.

The high rate of speed achieved by the circuit in computers is made possible by the use of the "surface-barrier" transistor. One of the principal advantages of this circuit is that it reduces manyfold the number of components. For example, diodes and vacuum tubes are entirely eliminated in an ordinary "flip-flop" circuit for a digital computer. The same electronic objective can be accomplished with a great saving in the number of parts, the number of wires, and soldered connections, at approximately 1/1,000 of the power requirements.

"The speed of computation is quite phenomenal. For example, addition or subtraction for 19 binary digits requires 2.4 microseconds, multiplication or division requires 48 microseconds, and the shift time is 0.4 microsecond.

"The logic of the machine is parallel

asychronous, which partially accounts for the extremely short computation times. The other factor is the speed capabilities of the surface-barrier transistor," Mr. Woods said.

In packaging a computer using the direct coupled circuitry, all elements required for addition, subtraction, multiplication, and division, as well as common control circuits, are combined on a single replaceable unit—a printed wiring card—having on it only transistors and resistors. No other electronic components are required in the arithmetic section of the computer. As the precision of the computer is increased, only cards need be added.

The control section of the computer will use cards similar in appearance to the digit cards. However, a few miniature capacitors are required.

The new Philco circuits are extremely useful in other circuitry related to the general electronics field with major use in digital computers, memory and selection systems, industrial control devices, and high-speed low-power switching systems.

GE Installs Automatic Control of Speaker Magnet Production

In approximately 16 feet of straight-line "automated space" today, all materials handling, mechanical inspection, and magnetic testing functions for speaker magnets, previously done in a 50-square-foot area, are centralized in two new electronically controlled machines installed recently in the Edmore, Mich., permanent-magnet plant of Carboloy department of the General Electric Company.

The two miniature "production" lines, automated by electronic tubes and a series of relays, already have tripled speaker magnet production in the plant by synchronizing production functions needed to transform the end-products well within range of industry standards.

With the aid of only two operators, they actuate belt conveyors, control drop chutes, hoppers, magazine feeders, aligning pushers, miniature gravity conveyors, and other devices for both mechanical inspection and magnetic testing—segregating and counting every magnet processed.

The mechanical inspection unit, which processes 2,100 speaker magnets per hour, a production pace three times faster than any technician can possibly work, provides facilities for visually inspecting for defects, then automatically checks the magnets for length, outside diameter, end-squareness, and parallelism. The machine holds both length and outside diameter to ± 0.001 inch and end-squareness under 0.002 inch.

Steady travel of the speaker magnets through the machine is controlled by a control switch inside the hopper, located at the left of the machine. As long as the hopper is full and the switch steadily actuated by the tumbling magnets in the hopper, no additional magnets are conveyed to the machine. Additional magnets are conveyed to the hopper automatically when the switch is no longer actuated.

During the checking sequence only those magnets that measure up to all specifications pass entirely through the machine for eventual shipping.

Any magnet failing to pass size specifications at any of the stations is automatically rejected at the point it fails to pass the test. For example, if the magnet is over or under size on length, it is automatically rejected at that point without going through the following checks for outside diameter and end-squareness.

Separate drop chutes built into the machine segregate magnets not coming up to standards at any of the checking stations. Solenoid control gates operated by circuits control the segregation operations.

The electronically controlled magnetic testing unit, which is located in line with the the mechanical inspection unit, operates in much the same manner as the latter. It processes about 1,600 speaker magnets per hour, and its function is to test the magnetic output of individual magnets.

The machine can be calibrated for various size magnets to test them in seven energy levels simultaneously, ranging from 3.5 to more than 6.5 million energy level.

In the magnetizing fixture of the machine, magnets are first magnetized, then tested by comparing them with a standard magnet of known value. They are then partly demagnetized and electronically segregated. As in the mechanical tester, several drop chutes are used in segregating them into proper containers located at the bottom of the machine.

OVER-ALL VIEW of two miniature electronically automated "production" lines recently installed by General Electric to step up mechanical inspection and magnetic testing of speaker magnets. Note bin and conveying setup at left of each unit to feed magnets to checking stations. Magnets are conveyed by 60-degree inclined cleated belt conveyors to drop chutes.

NSPE to Begin Construction of New Washington Headquarters

Excavation work has been started on the site of the new national headquarters building of the National Society of Professional Engineers in Washington, D. C. Ground was broken recently by C. T. Shoch, president of the society.

The approximately $300,000 4-story reinforced-concrete-frame granite-faced building located at 2029 K Street will house the executive and administrative offices and the offices of the *American Engineer*, monthly magazine published by the society.

The building project is being financed by the sale of building fund participation certificates to the membership, and the building is expected to be ready for occupancy by January 1, 1956.

Wind Tunnel Tests Show Need for Streamlining of Truck-Trailers

Tests conducted at the University of Maryland's wind tunnel prove streamlining of truck-trailers can save money. The tests were conducted by engineers from the University of Maryland and Trailmobile Inc., as a research project of the American Trucking Associations (ATA) Foundation, of which the company is a charter member. They show that wind resistance accounts for about one third of the horsepower it takes to pull large tractor-trailer units at 50 mph. The other factors which drain horsepower are rolling friction and chassis friction.

The wind tunnel scientists say it takes 58.3 hp to overcome wind resistance at 50 mph—the speed upon which the studies are based—for "boxy" trailers pulled by truck-tractors. The total required horsepower is about 160 according to Society of Automotive Engineers tests. Radical streamlining can reduce the 58.3 hp to 8.1 hp, and since there is a direct ratio between horsepower and gasoline consumption, this means a fuel savings of 30 per cent, with radical streamlining.

Radical streamlining does not seem likely in the near future, but truck operators will get an immediate bonus from the wind tunnel studies. The tests showed how conventional tractor-trailer combinations can now be streamlined enough to reduce total horsepower 6 per cent without cutting into cargo space.

How much this horsepower cut means in actual fuel dollars saved is controversial.

Some operators claim their truck-trailers average 50,000 miles per year at speeds of 50 mph over open highways; others claim as high as 100,000 at this average speed. The figures in the published wind tunnel study are based on 60,000 miles per year at 50 mph.

Based on the report's figures, a 6-per-cent horsepower reduction would pass on a fuel savings of $375 per unit per year over boxy-type trailers.

For years, truck drivers have been talking about "drag" caused by wind resistance. Drivers said some trailers "pulled hard," notably those with side posts on the outside. This information was taken into account by many trailer buyers, and their number was large enough to prompt Trailmobile to make a study of trailer wind resistance. Tests were started in 1953.

The wind tunnel study is the first major research project sponsored by the ATA Foundation, which was organized by the American Trucking Associations in 1953 during the presidency of W. F. Carey, chairman of the Foundation. Members of the Foundation are trucking industry suppliers who make grants to the Foundation for advertising, educational, and research activities under joint sponsorship of supplier and Foundation.

Paul Jung, Trailmobile's chief experimental engineer, headed the group that began the operation at the University of Maryland. Mr. Jung and Professor A. W. Sherwood, professor of aerodynamics and manager of wind tunnel research at the university, finished the first series of tests in June 1953.

These tests showed that truck drivers were not far wrong. Wind resistance of a truck-trailer is an important part of the tractive effect of a truck-tractor. But the tests did not provide much information about what specific areas were responsible for wind resistance. More than 7,000 combinations of tractor-trailer designs then were tested in the wind tunnel in an effort to find specific ways of reducing wind resistance.

The second phase of the tests showed that the greatest resistance was caused by the gap between the back of the tractor and the front of the trailer. Closing this gap reduced wind resistance by 25 per cent. Adding skirts cut it another 20 per cent. A long, streamlined "tail" on the back of a trailer reduced drag by 12 per cent, but the length of the "tail" makes it impractical under laws which now limit the length of motor vehicle units.

At the present time no one has suggested a practical way of closing the gap between the tractor and the trailer, but this area offers the most fertile filed for development.

The tests that have immediate application, and are the basis for estimating the $375 fuel savings, show marked decrease in wind resistance from rounding the front corners of the trailer. The big reduction comes when the corners are changed from square to an 18-inch radius, with another jump when the roof is rounded on the same radius in the front of the trailer.

The tests indicated that further rounding of the trailer front would not be practical, since the cubic capacity of the unit would be cut severely without a drop in wind resistance enough to make up the loss.

Trailers with vertical posts on the outside caused more wind resistance than smooth or horizontally corrugated trailers. Vertical posts cut the fuel savings on rounded corner trailers to $200. But between smooth and horizontally corrugated trailers there was surprisingly little difference.

When the wind tunnel scientists started working on the rear end of the trailer they expected to find it was another significant area for decreasing wind resistance. Some European studies, and known facts about aviation aerodynamics, led them to think they might get rid of the turbulence in this area that tends to "hold back" the trailer. But rounding the corners at the trailers' rear end and adding vanes on the side and roof to deflect the flow of air had little effect. The vanes even added some resistance.

The big problem now facing the trailer manufacturers is to adapt the wind tunnel studies to practical trailer design. While a truck fleet operator would welcome a tractor-trailer unit that could cut his fuel bill by 30 per cent he cannot afford to cut cargo space under laws that limit his vehicle size.

Con Edison to Have 138-Kv Isolated-Phase Bus Structure

The Consolidated Edison Company recently contracted with the R&IE Equipment Division of I-T-E Circuit Breaker Company for the world's largest bus structure, of the metal-enclosed isolated-phase type. It will have a voltage rating of 138 kv, and will serve to increase the facilities of the East River Station, New York, N. Y., where 69 kv is now in service.

PREVIEW of the early development of the new bus structure, comparing its size with the size of an average man.

Additional interconnections to other stations have been found desirable at East River, requiring a transmission voltage of 138 kv. Considerable past experience with metal-enclosed isolated-phase bus construction on the Consolidated Edison system, first with 13 kv, then with 27 kv, and later at 69 kv, has resulted in the selection of this type of construction for the new higher voltage bus and switch construction.

The new 138-kv bus structure will be built in preassembled sections of various lengths. It will have a current rating of 1,200 amperes continuous, and a momentary rating of 60,000 amperes.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Standards for Burma

To the Editor:

Living as we do in a country which, judged by Western standards, is a backward country, we have the opportunity of watching a transformation of ideas and outlook.

We have an agricultural nation now with 69 industrial projects, from steel making and hydroelectric projects to paper and jute making, backward in present application, but with tremendous outlook. True, Burma is not the only country with industrial vision—but it is with Burma that I am concerned. International tenders are now going out; there is great opportunity for anyone who is interested to quote bids on hydroelectric equipment, factory plants, generators, distribution schemes, etc. Now the question arises, "What equipment is going to be best for the country and by what standard is it going to be judged?" Obviously price is a consideration, but that is in the field of economics.

This is a tropical country so the obvious thing is that any plant must be made to withstand higher running temperatures and humidity of 95 per cent, and as far as motor and other windings are concerned, the ravages of insect life.

There are many standards—British standards, specifications of the India Standards Association, American standards, German V. E. D.—but it seems to me that American, British, and Indian are pretty much alike. I do think, however, that it is essential that if machinery of the highest quality is to be produced, it can be so produced only after careful study of the conditions under which the plant will work.

I have called for all these standards for, based on them, I wish to set up a standards institution for Burma. If I can obtain these, then possibly we may be able to give every bidder a fair chance of not only bidding on price, but on quality, and to standards required for Burma.

I shall be very glad to get your readers' reaction. . .

J. A. HILL (AM'55)

(Government Electrical Inspector, Ministry of Industry, Government of the Union of Burma, Rangoon, Burma)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

MODERN PHYSICS FOR ENGINEERS. Edited by Louis N. Ridenour. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1954. 499 pages, 9¼ by 6¼ inches, bound. $7.50. This collection of lectures, delivered at the University of California, 1952–53, provides a review of recent developments of interest to engineers. The lectures are arranged in three sections: The Laws of Nature, Man's Physical Environment, and Information and Its Communication. Typical subjects of individual lectures are solid-state physics, microwave spectroscopy, transient phenomena in supersonic flow, semiconductor electronics, and computing machines. Most chapters include lists of references.

MODERN PLASTICS ENCYCLOPEDIA ISSUE. Fourteenth Annual—1954. Plastics Catalogue Corporation, 575 Madison Avenue, New York 22, N. Y., 1954. 955 pages, 11⅓ by 8½ inches, bound. Available only to subscribers to *Modern Plastics* magazine. Articles by experts on engineering and methods, fabricating and finishing, machinery and equipment, and other branches of plastics technology have been brought up to date in this edition. The Technical Data section again includes a revised properties chart, and there is a new chart on plasticizers. The volume also includes a Directory Section with a classified buyers guide and alphabetical list of manufacturers.

NUCLEAR REACTORS FOR INDUSTRY AND UNIVERSITIES. Edited by Ernest H. Wakefield. Instruments Publishing Company, 845 Ridge Avenue, Pittsburgh 12, Pa., 1954. 93 pages, 8½ by 5½ inches, bound. $2. This book is a practical guide for those who wish to install a small research reactor. Eight authorities contribute chapters on the nature of nuclear energy, advantages of installing, types of radiation, control problems, prevention of radiation injury, and cost and legal factors. The cost study includes building, laboratory, and research expenses, but excludes fuel cost which is classified information.

PRICE MAKING AND PRICE BEHAVIOR IN THE PETROLEUM INDUSTRY. (Petroleum Monograph Series, volume 1.) By Ralph Cassady, Jr. Yale University Press, New Haven, Conn., 1954. 353 pages, 9¼ by 6½ inches, bound. $4.50. This monograph, the first in a series on the petroleum industry, deals with price-making procedures and results in the domestic market. Included in the study are an evaluation of the importance of petroleum in the economy; analysis of competition in the industry; detailed consideration of prices and pricing methods at the refinery, tank wagon, and retail level; and examination of the price structure as a whole in terms of interindustry price comparisons and profitability.

ASTM STANDARDS ON MATERIALS FOR RADIO TUBES AND ELECTRONIC DEVICES AND ELECTRICAL-HEATING, RESISTANCE, AND RELATED ALLOYS. The 1954 edition of this compilation includes in their latest form 44 widely used American Society for Testing Materials standards; 30 test methods, 10 specifications, and four recommended practices. Most of the standards have been developed through the work of ASTM Committee B-4 on Electrical-Heating, Resistance, and Related Alloys. Also included are related standards from other committees. Materials and subjects cover: electric-heating alloys; electric-resistance alloys; electric-furnace alloys; radio tubes, electronic devices, and lamps; heat-resisting alloys; electrical contact materials; and thermostat metals. 244 pages. $2.75. Write to American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

TELEVISION. The Electronics of Image Transmission in Color and Monochrome. By V. K. Zworykin and G. A. Morton. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., second edition, 1954. 1,037 pages, 9¼ by 6¼ inches, bound. $17.50. In the present edition of this detailed survey of the field the greatest emphasis is on the camera and viewing tubes, along with their physics background and the associated television fundamentals. In addition, specific aspects of circuitry, such as the video amplifier, are treated in detail. Most chapters have been rewritten and there are new chapters on color and industrial television.

THE THEORY OF THE PHOTOGRAPHIC PROCESS. By C. E. Kenneth Mees. Macmillan Company, 60 Fifth Avenue, New York 11, N. Y., revised edition, 1954. 1,133 pages, 9¼ by 6⅛ inches, bound. $21.50. Various authorities have collaborated in preparing this general handbook which is both a guide to the literature and summary of its conclusions. The subject is presented in five parts: photographic material, radiation action, optical sensitizing, development and after processes, and physics of photography. New chapters have been added and some of the historical material of the previous edition has been omitted, as has the chapter on photographic aspects of sound recording.

WORLD PETROLEUM STATISTICAL YEARBOOK. Volume 1: 1953/54 edition. Edited by Henry J. Struth. Mona Palmer, 604 Fifth Avenue, New York 20, N. Y., 1954. 452 pages, 11¼ by 8½ inches, bound. $20.00. Facts and figures accompanied by analysis of conditions and trends in the industry are supplied in this new directory. Three major divisions cover exploration, drilling, production, refining, transportation, and economics of petroleum and its products on a world scale, in the United States, and in foreign countries. Separate sections deal with taxation, employment, and investment and finance. There is a subject index.

TABLE OF THE GAMMA FUNCTION FOR COMPLEX ARGUMENTS. (Applied Mathematics Series, no. 34.) National Bureau of Standards. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C., 1954. 105 pages, 10½ by 8 inches, bound. $2.00. This table gives $\log_{10}\Gamma(x+iy)$ to 12 decimals for values of x and y from 0 to 10, at intervals of 0.1, and from the table the values of $\Gamma(z)$ in the corresponding squares of three other quadrants can be obtained. The volume also includes an explanatory introduction and a bibliography of related tables and general references.

CIRCUITS AND NETWORKS. By Glenn Koehler. Macmillan Company, 60 Fifth Avenue, New York, N.Y., 1955. 349 pages, 9¼ by 6⅛ inches, bound. $6.50. This introductory textbook covers network theorems; simple-frequency selected circuits; coupled circuits; 4-terminal networks and impedance matching; filters; attenuators and equalizers; transmission-line parameters and analysis; high-frequency transmission lines; transformers; and reactors. An introductory chapter reviews methods for analyzing and solving circuits and networks.

DAVISON'S TEXTILE BLUE BOOK. 89th year, 1954. Davison Publishing Company, Ridgewood, N. J., 1954. 1,411 pages, 8¼ by 5 inches, bound. Handy edition $6.50. A comprehensive annual guide to the textile industry of the United States and Canada with a section listing foreign raw cotton firms. New mills and firms, laboratories, and manufacturers have been added since the last edition. An alphabetical index of mills, dyers, finishers, etc., is provided, and the various sections are thumb indexed for convenient use.

DEVELOPMENT OF THE GUIDED MISSILE. By Kenneth W. Gatland. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y., second edition, 1954. 292 pages, 8½ by 5⅝ inches, bound. $10.00. A survey of the evolution of guided missiles up to the present time and a description of their possible future development. Methods of propulsion of rockets and ram-jets, current methods of research, and both military and peaceful applications of various types of missiles are discussed, with consideration given to rockets for high-altitude research, space satellites, and interplanetary flight. Appendixes give comparative data on 140 rockets from 8 countries and scale photographs of over 40 notable rockets.

THE GYROSCOPE APPLIED. By I. I. T. Richardson. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y., 1954. 384 pages, 9¼ by 6¼ inches, bound. $15.00. The subject is treated in five sections covering fundamentals and general applications; marine, aeronautical, and military applications; and uses on land for such devices as monorail and 2-wheeled vehicles, and for surveying. Descriptions of a wide range of devices—from small aircraft instruments to roll-stabilizers for ocean liners—are clarified by free use of photographs and diagrams. Use of mathematics is avoided as far as possible in the descriptions, but fundamental laws are discussed in an appendix.

PAMPHLETS

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Dielectric Quarter-Wave and Half-Wave Plates in Circular Waveguide. Conversion of linear to circular polarization, rotation of the plane of a linearly polarized wave, and changing a circularly polarized wave from right- to left-hand circular (and vice versa), are among the properties of quarter- and half-wave plates described in this Government report. The new plates are polystyrene slabs, tapered to reduce reflections, and are mounted in a diametral plane of the circular waveguide. The quarter-wave plates have differential phase shifts of between 88 and 92 degrees from 8,750 to 9,700 mc. Half-wave plates have a phase shift of between 176 and 186 degrees from 8,200 to 10,000 mc. The plates were also incorporated in a rotary phase shifter, whose calibration and performance are discussed in detail. 22 pages. $.75. For copies, send to the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. (Commerce Building, Room 6227.) Report code number is PB 111271.

An Underwater Television System. A self-propelled submerged pickup camera controlled from shipboard is featured in a new underwater television system described in a report from the Radio and Electrical Engineering Division of the National Research Council of Canada, Ottawa. The new "remote-eye" system holds promise as an extremely valuable tool for safe underwater exploration by marine geologists, biologists, construction engineers, oceanographers, and fishermen. Not subject to the limitations of divers and sounding equipment, the new system offers possible applications in salvage operations, location of mineral deposits and marine-life concentrations, fishery developments, and maintenance of underwater structures. It has been successfully used at depths up to 100 feet, the depth for which this model was designed. Many additional uses will undoubtedly develop as instrument and depth range are improved. 12 pages. Microfilm $1.75. Photostat $2.50. "An Underwater Television System" is available from the Library of Congress, Publication Board Project, Washington 25, D. C. Make check or money order payable to the Librarian of Congress, Washington 25, D. C.

Understanding High Fidelity. This is a new and enlarged edition published by The David Bogen Company, Inc., New York, N. Y., manufacturers of custom high-fidelity home-music systems. The second enlarged edition of "Understanding High Fidelity" follows the pattern of the original edition. The first explains what high fidelity is in terms understood by the layman, while the second section tells the average person about the numerous types of equipment and how to use them in making a custom home-music system. 25¢. Write to: The David Bogen Company, Inc., 29 Ninth Avenue, New York 14, N. Y.

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INDUSTRIAL NOTES ....

General Electric News. The General Electric Company plans to build a new plant at Irmo near Columbia, S. C., to produce aluminum electrolytic capacitors. The plant will cost about $6,400,000 and will occupy a 135-acre site. The plant will eventually employ about 700 persons.

A. Eugene Schubert has been named manager—engineering, of the company's chemical materials department. Dr. Schubert helped create plans for General Electric's new silicone plant at Waterford, N. Y. On this project he aided in engineering design of the plant's distillation area. In 1945, he became head of the Research Laboratory's Chemical Process Section. He will make his headquarters at 1 Plastics Avenue, Pittsfield, Mass.

Appointment of Ray E. Horner as central district sales manager for the light military electronic equipment department (LMEE) has been announced. Mr. Horner, a former lieutenant-colonel in the United States Air Force, will make his headquarters at 410 West First Street, Dayton, Ohio. He will represent the LMEE department with its military and industrial customers for air-borne and other specialized light electronic equipment. In his new position he succeeds Roy L. Merwin, Jr., who recently joined the sales organization of the components department, Syracuse, N. Y.

H. M. Norton has been named supervisor, commercial service, for the Plainville, Conn., plant of the distribution assemblies department. Mr. Norton will be responsible for the administration of all commercial service activities at the Plainville plant.

Honeywell, Raytheon Set Up Joint Company. Minneapolis-Honeywell Regulator Company and Raytheon Manufacturing Company have entered into a joint undertaking to engineer and market large high-speed electronic data-processing systems for use in business and government. The project will be carried out through the formation of a jointly owned corporation, to be known as Datamatic Corporation. Honeywell will have a 60-per-cent, and Raytheon a 40-per-cent, interest in the new corporation. The new firm, to be headquartered in Waltham, Mass., will have its own administrative officers and directors.

Roller-Smith News. The Instrument Division of the Roller-Smith Corporation, Bethlehem, Pa., has announced the appointment of Quality Electric Company, 2212 South Hill Street, Los Angeles, Calif., as its West Coast repair station. Quality Electric Company will service and repair meters for Roller-Smith customers in the western section of the country.

The Instrument Division has named Lloyd Hawksworth as its new chief industrial engineer. Mr. Hawksworth, an industrial engineering graduate of Rutgers University, was associated with Westinghouse Electric for 16 years, where the scope of his work covered the manufacture of lamps, meters, instruments, and relays.

Varo Buys Schuttig Company. Varo Manufacturing Company, Inc., of Garland, Tex., has purchased the Schuttig Company of College Park, Md., which will move to Garland as a division of Varo. The integration of the two companies permits Varo to cover a broader field of electronics design and manufacture than was possible for either company before the consolidation. Under the reorganization Robert L. Jordan, formerly vice-president and general manager, becomes executive vice-president. Leonard A. Schuttig, formerly head of the Schuttig Company, will join Varo as vice-president of the new Schuttig Division. The other vice-presidents will be Luther B. Nichelson, finance; Fred P. Granger, Jr., customer relations; Jack G. Smith, engineering; and Walter J. Jagmin, manufacturing.

Houghton Laboratories Notes. Donald Roon has been elected executive vice-president of Houghton Laboratories, Inc., Olean, N. Y. Prior to joining Houghton Laboratories, Mr. Roon was vice-president of marketing at Nuodex Products Company, Inc., Elizabeth, N. J.

Donald Rice has been named a member of the research staff in chemistry at the Research Division. Mr. Rice spent 3 years with Nash-Kelvinator, specializing in coatings and refrigeration. The past 3 years he was with the Vanadium Corporation of America doing research on metals.

Cornell-Dubilier Changes. Cornell-Dubilier recently opened its new plant in California. The modern dome-shaped building will house the West Coast Division of the Cornell-Dubilier Electric Corporation. Located at 4144 Ocean Park Avenue in Venice, Calif., it will house both an electronic development laboratory and a pilot plant.

Formation of a Printed Wiring Division at South Plainfield, N. J., devoted exclusively to the design, development, and manufacture of printed circuitry, has been announced.

Merger Planned. The merger into General Dynamics Corporation of Stromberg-Carlson, subject to the approval of the share owners of both corporations, has been announced. No changes in the management of either corporation are contemplated. Stromberg-Carlson will retain its name, individual identification, and organizational structure except that it will operate within General Dynamics as the Stromberg-Carlson Division. Robert C. Tait, now president of Stromberg-Carlson, will continue as president of the division and will also become a senior vice-president of Dynamics. Mr. Tait, Wesley M. Angle, chairman of Strom-

(*Continued on page 20A*)

Comvor
DATA TRANSMISSION Terminal

Multi-Purpose, Star Performer for Transmitting Signals to Remote Locations
over WIRE LINES, TELEPHONE LINES, MICROWAVE and POWER LINE CARRIER Circuits

Model 912 has Wide Industrial Applications in **TELEMETERING and SUPERVISORY CONTROL**

Comvor Features

1 RELIABLE
The frequency shift method of keying is used for greater reliability under conditions of noise and varying signal levels. Circuits are all electronic and no relays are used.

2 ECONOMICAL
The same basic chassis are supplied on all channels. Printed circuits and plug-in filters are used to permit future changes and expansion.

3 COMPACT
The complete terminal measures 3½ x 19 x 8 inches for mounting on a standard relay rack.

4 VERSATILE
Transmits and multiplexes signals derived from frequency and pulse duration type telemeters. Used for remote control of virtually an unlimited number of functions from a central location. Uses common communication facilities for transmission: wire and telephone lines, microwave, and power line carrier. Terminals available as transceivers, dual transmitters, or dual receivers.

The Model 912 Comvor is an audio frequency shift terminal which provides the means for simultaneous transmission of telemetering and supervisory control signals over a single communication facility. Up to 60 individual information channels are available in the audio spectrum. Because of its reliability the frequency shift method of keying is used. Audio voltages are being transmitted at all times and therefore the noise normally found on communication circuits must become equal to or greater than the audio signals before information errors occur. Limiting amplifiers are used to permit operation with line levels varying from 0 to —40 dbm without affecting the data or information being transmitted.

The equipment design was based on a survey of field requirements which resulted in a compact inexpensive unit adaptable to most telemetering and control requirements. All essential controls such as transmitter output level and receiver input level are included in the equipment. Each equipment contains its own power supply which provides an additional sixty milliamperes at both the transmitter and receiver for the operation of relays, stepping switches, and other components used in control applications. A "mark-hold" circuit, which provides the basis for fail-safe operation in telemetering and supervisory control applications, is a design feature included in each receiver.

Write for technical data and application information.

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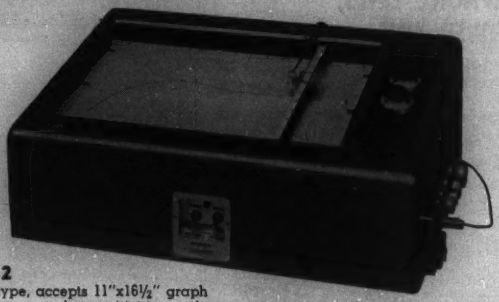
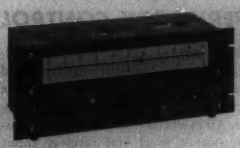
AUTOGRAF Recorders, MODELS 1 and 2, provide all the features needed for graphic recording of test data, point plotting, and curve following for readout purposes.

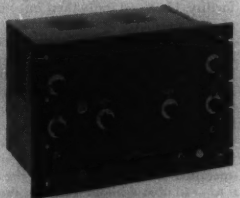


MODEL 2
Flat bed type, accepts 11"x16½" graph paper; same speeds, sensitivities and ranges as MODEL 1; zero set anywhere on paper plus one full scale length of zero-offset; inputs provided for analog recording, point plotting from digital sources, and curve following for computer or data reduction use.



MODEL 20 DC VOLTMETER is a servo-actuated, fast, accurate and sensitive instrument. Has large, easy-to-read scale for general laboratory use where ranges from 3 millivolts to 300 volts are desired. For data handling it is furnished with a built-in Coleman digitizer and delivers digital output for operation of printers, typewriters, tape or card punches, etc.

MODEL 30 CARD TRANSLATOR converts information from punched cards into point form for automatic plotting. Handles up to 50 cards per minute, 10 to 200 counts per inch. Plugs directly into MODEL 2 recorder, controls both card reader and recorder for completely automatic operation.



MODEL 40 KEYBOARD provides a convenient means for plotting large amounts of tabular data in point-curve form. Self-contained voltage source together with full three column keyboard in both X and Y axes; unit plugs directly into MODEL 2 AUTOGRAF.

Bulletins describing these instruments are available and we'll be glad to send them to you. Write . . .

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(Continued from page 18A)

berg-Carlson's board, and Bernard E. Finucane, president of Security Trust Company of Rochester, N. Y., and also a member of Stromberg-Carlson's board, will become members of General Dynamics's board. Mr. Tait will also serve on the management committee of the board of directors and Messrs. Angle and Finucane on the advisory committee thereof.

Mag-Electric Acquisition. Mag-Electric Products, Inc., of Hawthorne, Calif., has acquired all of the assets of Mag-Electric Networks, Inc. This acquisition will broaden the company's line of components for aircraft, missile, electronic, laboratory, computer, and commercial use. All engineering and production personnel of Mag-Electric Networks, Inc., have been retained.

Vice-President Elected. Warren Edman, manager of street lighting of Holophane Company, Inc., has been appointed vice-president in charge of street lighting. His base of operations will remain at Newark, Ohio, where the factory and engineering center are located.

Texas Instruments Acquires Radell. Purchase of the business and assets of the Radell Corporation of Indianapolis, Ind., has been announced by Texas Instruments, Inc., Dallas. The transfer of production operations to the Texas Instruments Dallas operation is being scheduled so that deliveries to Radell's customers will continue uninterrupted. J. P. Rodgers, Jr., is general manager of the Texas Instruments Components Division, which will manufacture and market the Radell resistors. John R. Pies, former Radell manager, will join Texas Instruments as chief engineer of the Components Division.

Raytheon Opens Canadian Office. The Raytheon Manufacturing Company, Waltham, Mass., has announced the opening of a central office at Toronto, Ont., for its operation in Canada. The office is located at 119 Bay Street, and will be under the management of John R. Cann.

Elgin Buys Advance Relay. Elgin National Watch Company has purchased Advance Electric and Relay Company of Burbank, Calif. It is the company's second acquisition in the relay field. Elgin began diversification into the miniature electronic components field last October with the purchase of Neomatic, Inc., of Los Angeles, Calif., makers of subminiature relays. Recently, the firm bought American Microphone Company, Pasadena, Calif., manufacturers of microphones, photographic pickups, and cartridges. Officers will remain with the company temporarily on a consulting basis. Advance will be under the general direction of A. P. Barton, general manager of Elgin Neomatic, Inc.

(Continued on page 28A)

High Pressure . . . Oil filled
POTHEADS by G&W

Proper treatment of mechanical and electrical stresses permit this simple G&W design. Full 200 pound pipe line oil pressure is retained by the relatively small bore porcelain shell. Tested at 500 p.s.i. pressure. No castings are used for withstand of pressure. Top and bottom fittings are fabricated, non-magnetic, stainless steel—sealed by fully retained "Resistoyl" gaskets.

Stress relief cone, supplemented by porcelain stress control tube, makes efficient use of the internal diameter and length of porcelain shell—and reduces the amount of installation labor.

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COLLYER INSULATED WIRE CO.
245 ROOSEVELT AVE.
PAWTUCKET, R. I.

(*Continued from page 20A*)

Three Appointments. Three appointments to higher posts at Arma Division of American Bosch Arma Corporation, Garden City, N. Y., have been announced. Clifton T. Foss has been named division vice-president and general manager. Edmund D. Gittens was made vice-president and chief of the Arma Division. Clarence H. Hopper was made vice-president—manufacturing of the Arma Division.

New Director Systems Department. The formation of a director systems department in Westinghouse Electric Corporation, responsible for the engineering, manufacture, and sale of specialized automatic control systems, has been announced. Director systems, are control systems with no moving parts which have been developed by Westinghouse for industrial control applications. Named as manager of the department is L. W. Golden. He joined Westinghouse in 1946 through the graduate-student training course, and has worked on various assignments in the materials engineering department. Headquarters for the director systems department will be located in the Pittsburgh, Pa., area.

Daystrom-Weston Merger. Directors of Daystrom, Inc., and Weston Electrical Instrument Corporation have signed an agreement of merger under the terms of which Weston would be merged into Daystrom. It is planned that the business and assets acquired from Weston will be transferred to a wholly owned Daystrom subsidiary to be named Weston Electrical Instrument Corporation. The Weston operations will be continued under the same management and personnel as at present, and the Weston name will be retained on its products.

Heinecke Named Manager. Appointment of Harold H. Heinecke as manager of Allis-Chalmers commercial research department has been announced. Mr. Heinecke has been assistant manager of the department since 1951. He has been active in the Milwaukee chapter of the American Marketing Association, and is a past president of the group.

NEW PRODUCTS . . .

Germanium Power Rectifier. International Rectifier Corporation, El Segundo, Calif., has announced the availability of a 35-kw liquid-cooled germanium power rectifier, type *53-0075-0*. This new product is a 3-phase bridge unit, rated for a maximum of 450 amperes d-c continuous output and can be supplied for input voltages of 26, 36, 52, and 66 volts rms

(*Continued on page 36A*)

AIEE SPECIAL PUBLICATIONS

To meet a specialized need, or where it has become advantageous to collate a number of papers on a subject in one pamphlet, a series of special publications has been established. Prices quoted are (M) for AIEE members, and (N) for nonmembers.

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S60	CIGRE Report on Corona Losses (7/52)		.75	.75
S73	Classified Bibliography on Insulated Conductors Beginning With 1930 (6/54)		1.00	1.00
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S19	Electric Power in the Pulp and Paper Industry (2/48)		.50	1.00
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S50	Electronic Converter Applications and Tubes (7/52)		3.50	3.50
S25	Elements of Nucleonics for Engineers (3/49)		.60	1.20
S2	Grounding Principles and Practice (6/45)		.50	.50
S54	Joint AIEE/IRE Conference on Telemetering and Remote Control (4/53)		3.50	3.50
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S55	National Telemetering Conference—1953		2.00	2.00
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S66	Symposium on Higher Distribution Voltage for Metropolitan Areas (9/54)		2.00	2.00
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S17	The Electrical Engineer		no charge	
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S22	Tidd 500-Kv Test Project (1/48)		.50	1.00
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*An AIEE Conference Report, consisting of the full texts of the papers and discussions presented at a special AIEE technical conference on the subject

Also available is the following publication, issued by EJC (Engineers Joint Council) of which AIEE is a member:

S13	Engineering Profession in Transition (1947)		.50	1.00

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ULTRA-HIGH FREQUENCY OPERATION . . . Frequencies covered include UHF and color television assignments and Citizen's Band. Used by TV transmitter engineers for plotting antenna patterns, adjusting transmitters and measuring spurious radiation.

RECEIVING APPLICATIONS . . . Excellent for measuring local oscillator radiation, interference location, field intensity measurements for fringe reception conditions and antenna adjustment and design.

SLIDE-BACK CIRCUIT . . . This circuit enables the meter to measure the effect of the peak value of an interfering pulse, taking into account the shaping due to bandwidth.

QUASI-PEAK FUNCTION . . . An aid in measuring pulse-type interference, the Quasi-Peak function is just one of the many features of this specially designed, rugged unit, representing the ultimate in UHF radio interference-field intensity equipment.

ACCURATE CALIBRATION . . . Competent engineers "hand calibrate" each NM-50A unit. This data is presented in simplified chart form for easy reference.

SENSITIVITY . . . Published sensitivity figures are based on the use of the NM-50A with a simple dipole antenna or RF probe. However, the sensitivity of this fine instrument is limited only by the antenna used. The sensitivity of the NM-50A is better than ten microvolts across the 50 ohm input.

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NM-10A, 14kc to 250kc
Commercial Equivalent of AN/URM-68. Very low frequencies.

HF NM-20B, 150kc to 25mc
Commercial Equivalent of AN/PRM-1A. Self-contained batteries. A.C. supply optional. Includes standard broadcast band, radio range, WWV, and communications frequencies. Has S-Meter.

VHF
NM-30A, 20mc to 400mc
Commercial Equivalent of AN/URM-25. Frequency range includes FM and TV bands.

STODDART AIRCRAFT RADIO Co., Inc.
6644-B Santa Monica Blvd., Hollywood 38, California • Hollywood 4-9294

(*Continued from page 28A*)

maximum. The type *53-0075-0* has a volume of approximately 220 cubic inches as compared to 1,650 cubic inches for a comparable selenium unit (fan cooled) and 14,000 cubic inches for a copper-oxide unit (fan cooled). This unit requires liquid coolant (water, oil, etc.) at a maximum inlet temperature of 25 C and a volume of 1/2 gallon per minute minimum. For further information write to the manufacturer.

Cockpit Light. A new multiple-use cockpit light provides four different beams—flood or spot, white or red. Beam selection is made by a simple turn of the light's indexed cap. Additional features include a built-in rheostat for intensity control and a small push button that overrides the rheostat to provide a full bright light. Designed and produced by Grimes Manufacturing Company, the unit, designated *D-6870A*, has a detachable base and self-coiling cord. The complete line of Grimes aviation lighting equipment is available at all Air Associates, Inc., branches.

Magnetic Starter. A new National Electrical Manufacturers Association size 4 vertical-lift magnetic starter, 40 per cent smaller than previous models of the same size, has been announced by the General Electric Company. Strongbox coil design includes a cast-on plastic case for maximum protection of coil windings. A permanent air gap causes the starter to drop out when de-energized regardless of age and usage, and a new type of bimetallic overload relay provides overload protection comparable to that available in smaller sizes. Suitable for operation of polyphase motors in ratings of 220 volts, 50 hp, and 440/550 volts, 100 hp, the new starter is available in reversing, multispeed, and combination forms, and can be obtained with either vertical or horizontal mechanical interlocks.

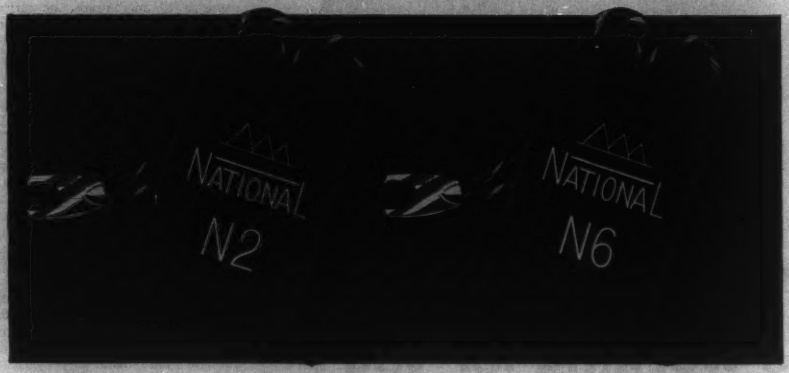
Pressure Transmitter. G. M. Giannini and Company, Inc., announces the production of a new model *47155* pressure transducer, designed for industrial applications requiring an electric output proportional to pressure. Utilizing a pressure capsule that operates the wiper of a precision potentiometer in direct proportion to applied pressure, this instrument is available in ranges up to 100 pounds per square inch, for absolute, gauge, and differential pressure measurements. Outputs up to 40 volts can be obtained, and it can be used to operate indicating recording or control devices with little or no amplification. Standard resistance is 2,000 ohms, with a power rating of 0.5 watt. Accuracies to 0.8 per cent and sensitivity to 0.4 per cent can be obtained.

Arc-Angle Switchboard Meter. The Roller-Smith Corporation has announced production of a new 250° arc-angle switchboard meter designed to provide extra compactness and ease of reading, while incorporating a completely new move-

(*Continued on page 38A*)

FIRST AGAIN!

NEW NATIONAL BRUSH GRADES BEAT HIGH-TEMPERATURE CONDITIONS IN SILICONE-INSULATED MOTORS AND GENERATORS



ELECTRICAL DESIGN ENGINEERS are welcoming two new grades of "National" motor brushes—N-2 and N-6—as the answer to high-temperature dusting of brushes in totally-enclosed, general-purpose motors and generators having class H (Silicone) insulation.

GRADES N-2 and N-6, first brushes specifically designed to resist silicone vapors at elevated temperatures, handle a wide range of commutation requirements. Originally formulated for a special military application, results were so favorable that these new grades are now part of the complete "National" brush line.

WHEN YOU BUY BRUSHES, remember this—there are more "National" brushes on rotating d.c. equipment than any other brand! Whatever your needs, there are "National" brushes that will help your equipment do a better job at the lowest overall cost.

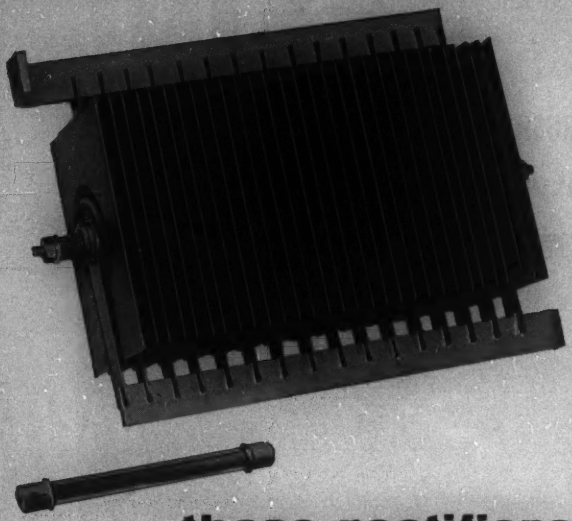
Yours for the asking... **National Carbon's instructive pamphlet series on the practical aspects of motor and generator maintenance. Supervisors should request as many copies as they need to distribute personally to their men.**

The term "National", the Three Pyramids Device and the Silver Colored Cable Strand are registered trade-marks of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.

Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco
IN CANADA: Union Carbide Canada Limited, Toronto

Did you know...



...these rectifiers are working for you every day?

They are powering radio equipment in airplanes...electroplating parts for your next car...What is your application? We have the right rectifier for it.

Rectifier Sarkes Tarzian INC. **Division**

Dept. E3, 415 North College Ave., Bloomington, Indiana

In Canada: 700 Weston Rd., Toronto 9, Tel. Murray 7535

Export: Ad Auriema, Inc., New York City

(*Continued from page 36A*)

ment. Unusually accurate readings are made possible by an exceptionally long scale, $2^1/_2$ times greater than conventional scales. For further information, contact E. S. Maury, Sales Manager, Instrument Division, Roller-Smith Corporation, Bethlehem, Pa.

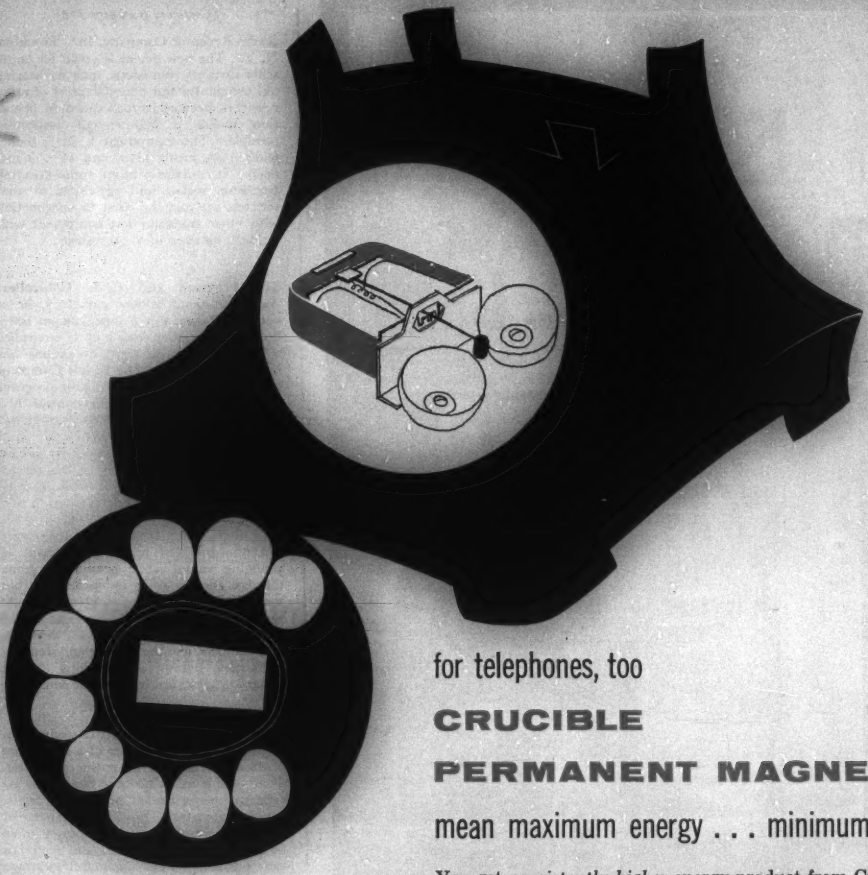
Miniature Quartz Crystal. A new miniature quartz crystal is now in production for electric equipment manufacturers. Its size is 3/4 inch wide, 1 inch long, and 3/4 inch thick. The unit, designated as *6N175*, has a frequency range of 80–150 kc; temperature range −40 C to +70 C; frequency tolerance ±0.012 per cent; load capacity 20 microfarads, or series resonance; holder type *HC-6/U*. Crystals are ultrasonically cleaned and hermetically sealed. For further information write Cryco, Inc., 1138 Missiou Street, South Pasadena, Calif.

Duplex Receptacle. The Arrow-Hart and Hegeman Electric Company, announces the availability of a new grounding-type duplex receptacle with parallel slots, which is suitable for use whenever electric equipment should be grounded as protection for the users. This receptacle, type *5252*, can accommodate both grounding- and regular-type parallel blade caps, and is side-wired with a contact breakoff for 2-circuit installation. For conventional wiring, it is equipped with large binding screws. When used with metallic wiring systems, grounding is directly through the metal enclosure. Used with nonmetallic wiring systems, grounding is through a third wire acting as a grounding conductor. This receptacle has a special U-shaped slot for the ground blade, and a hexagonal green screw to which the third grounding wire is attached. Catalog Sheet *26-E*, giving complete information on the duplex receptacle, may be obtained by writing Sales Department, The Arrow-Hart and Hegeman Electric Company, Hartford 6, Conn.

Apparatus Bushings. A new series of special high-voltage apparatus bushings for corona-free operation is now available in six voltage ratings of 25, 50, 75, 100, 125, and 150 kv. Designed for use in test transformers, d-c and special high-frequency applications, bushings are oil-filled and consist of a large-diameter porcelain housing, completely sealed. A conductor extends through the porcelain and is specially designed to avoid internal corona. External corona is eliminated by careful design including both porcelain and metal shielding. A bulletin describing these and other Lapp bushings is available on request from Lapp Insulator Company, Inc., Le Roy, N. Y.

Transistor Noise Meter. A simplified transistor noise meter, which furnishes for the first time accurate information on the noise figure of a transistor in a single simple reading by simply inserting the transistor into a socket, has been developed by the

(*Continued on page 42A*)



for telephones, too

CRUCIBLE

PERMANENT MAGNETS

mean maximum energy . . . minimum size

You get *consistently higher* energy product from Crucible *prescription-made* alnico permanent magnets.

That means more energy from a smaller magnet . . . greater design freedom for manufacturers of telephone sets, high-fidelity sound equipment, controls, instruments, and magnet-equipped devices of all kinds.

Crucible, the nation's leading producer of *special purpose steels*, has been making these quality magnets ever since the development of alnico alloys. They're available sand cast, shell molded, or investment cast to meet every size, tolerance, shape and finish need.

For prompt delivery – or helpful advice on magnet problems – call Crucible. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

ELECTRONS, INCORPORATED
127 SUSSEX AVENUE
NEWARK 3, N. J.
EL C16J thyratrons provide instantaneous electronic control of latest Harnischfeger electric shovel.

(*Continued from page 38A*)

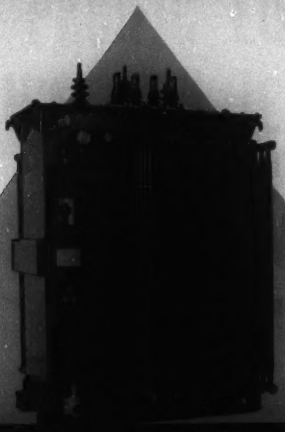
Radio Receptor Company, Inc., Brooklyn, N. Y. The new device is useful for large-scale users of transistors, such as hearing aid companies and manufacturers of radio receivers, because its high speed of operation makes a 100-per-cent inspection possible. The equipment is 21½ inches wide, 10⅞ inches high, and 16¼ inches deep. It contains a novel, rapid-insertion transistor socket and provision so that the test set may be used in conjunction with other transistor test equipment with a single insertion of the transistor.

Time-Program and Cycle Controller. An instrument which combines in a compact 2-case unit a 2-pen 2-cam time-program controller with a cycle controller which times up to eight operations has been announced by The Bristol Company of Waterbury, Conn. The time-program controller can be used to control two variables such as temperature, humidity, pressure, or vacuum through any predetermined program of values by means of an aluminum cam cut to the proper shape. Each of the two cams is individually cut, and locked together in any desired time relationship to each other on a single hub. In this way, temperature can be controlled through one cycle of changing values while pressure is going through another cycle independently, but synchronized with the temperature. At the same time, such operations as the opening and closing of valves, switches, and dampers, and the starting and stopping of motors, pumps, and blowers can be automatically timed by the cycle controller.

Ceramic for Microwave Attenuation. AlSiMag *624* is a member of a new series of ceramics for use as power absorbers. Tests of this material have established its superior performance as a microwave energy absorber. It is recommended where 10 watts or more of power must be handled, and where organic materials are unstable. The maximum wattage absorbed depends on provisions for dissipation of heat. The manufacturer can formulate ceramic materials to meet a wide range of dissipation factors and volume resistivities for specific attenuation requirements. Test samples of AlSiMag *624* and condensed data sheet sent on request. Write to American Lava Corporation, Chattanooga 5, Tenn.

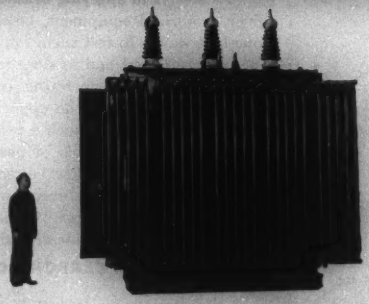
Cathode-Ray Tube for View Finder. A direct-viewing 5-inch cathode-ray tube designed for use as a view finder on portable television cameras has been announced by the Radio Corporation of America. The tube (*RCA-5AYP4*) provides a 3⅜-inch by 2½-inch image of the televised scene. Focused electrostatically and deflected magnetically, it has an electron gun designed to provide high resolution and uniform focus over the entire picture area. Maximum design-center rating for the ultor of the *RCA-5AYP4* is 10,000 volts and for the focusing electrode 1,500 volts.

(*Continued on page 48A*)



UPTEGRAFF **POWER** TRANSFORMERS

PROMPT DELIVERY... FULLY GUARANTEED



A complete engineering department and a modern, fully-equipped plant give Uptegraff the facilities it takes to provide fast service on power transformer production—even those of special design.

Available in sizes up to 10,000 KVA, 115 KV, every Uptegraff transformer meets or exceeds ASA, NEMA and AIEE standards and is fully guaranteed by our company.

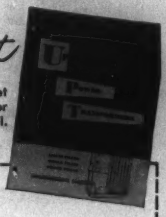
These two advantages are yours when you order Uptegraff transformers for your power needs. And when the unit is delivered and installed, you have one of the finest built pieces of electrical equipment in the country—rugged, leakproof, undercoated, and performance tested.

You can order Uptegraff Power Transformers with standard accessories; terminal arrangement, cooling fans, wheels, oversize bushings and many other special accessories are optional.

If you're getting ready to replace or add to your transformer installations, Uptegraff can serve you well and quickly.

Send for Data Booklet

Use coupon below or your letterhead and get this comprehensive ENGINEERING MANUAL for executives, engineering and operating personnel.



R. E. Uptegraff Manufacturing Co.
Scottdale, Pennsylvania

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EE

Announcing a BIG IMPROVEMENT

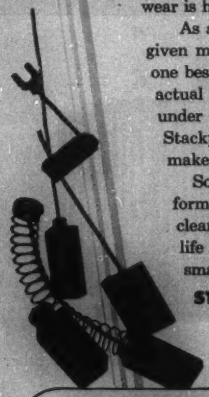
IN SMALL MOTOR BRUSHES

Exhaustive tests indicate that Stackpole Grade 373 fractional horsepower motor brushes represent a major development in their field. On vacuum cleaners, food mixers, sewing machines, calculators, and similar equipment, these new brushes have shown *materially* longer life, usually with better performance than any previous grades. Commutator wear is held to a minimum.

As always in applying brushes to any given motorized equipment, however, the one best way is to test them fully on that actual equipment and as close to possible under its typical operating conditions. Stackpole welcomes the opportunity to make or to facilitate such a test for you.

Solely on this basis of positive performance proof, it now becomes pretty clear that Grade 373 brushes will set new life and performance standards for small motors in a wide diversity of uses.

STACKPOLE CARBON COMPANY,
St. Mary's, Pa.



STACKPOLE
Grade 373
FAR LONGER BRUSH LIFE - *Plus*
EQUAL (OR BETTER) PERFORMANCE THAN PREVIOUS GRADES

(Continued from page 42A)

A-C Clamp Volt-Ammeter. A lightweight pocket-size clamp volt-ammeter, with a single easily read scale for all ranges and functions and employing a special shock-mounted instrument movement, has been introduced by the Weston Electrical Instrument Corporation, Newark, N. J. Known as the model *749*, this new instrument incorporates a self-shielded mechanism with spring-backed jewels, which is effectively shock-mounted within the Bakelite case. To simplify reading, only a single scale is employed for all ranges and functions which are selected through a convenient positive-action thumb selector switch. The neoprene-covered clamping jaws, tapered for measurements in limited areas, and with precision ground faces for positive contact, require but slight pressure on the gradient-controlled spring trigger for opening and closing. It accommodates conductors up to 1 inch round or $1\frac{1}{4}$ inches by 3/8 inch rectangular. The instrument contains six current ranges of 300, 150, 60, 30, 15, and 6 amperes, and three voltage ranges of 600, 300, and 150 volts.

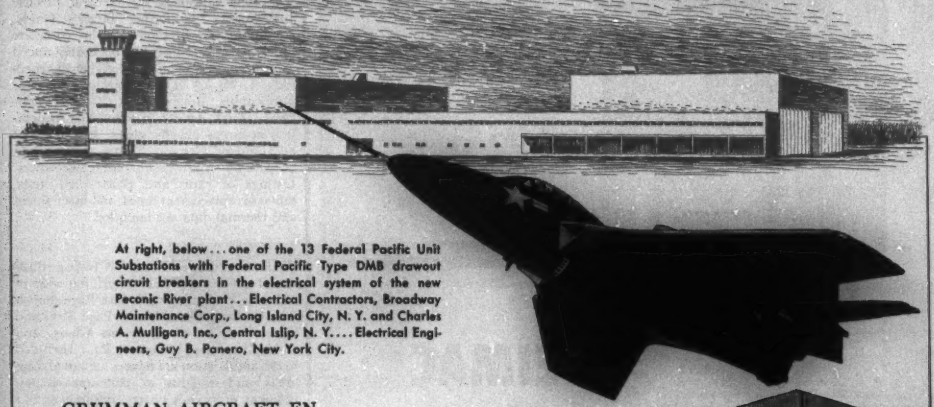
Portable Oscillographs. Lightweight portable oscillographs are the new developments in the field of recording systems announced by the Brush Electronics Company, Cleveland, Ohio. A 4-channel oscillograph weighs 36 pounds and a 6-channel recorder is 48 pounds. Despite their light weight and compactness, either model provides full-range instrumentation. Designed for flexibility, each unit offers a range of 16 chart speeds with the travel variation of from 10 inches per day to 10 inches per second to simplify the testing problems of electrical variables, vibration, torque, stress, strain, and other desired measurements. Engineered into the models are a control selector that will permit either a local or remote control setup.

TRADE LITERATURE

Control Element. The magnetically operated glass-enclosed Revere GLASWITCH, a sensitive control element for general industrial applications, is described in Engineering Bulletin *1057* available from Revere Corporation of America, Wallingford, Conn. The 20-page booklet covers operation, performance, and characteristics of the $2\frac{1}{2}$ inch long, hermetically sealed switch, which is designed to operate in any position in 1 millisecond or less at rates as high as 400 cycles per second. Methods are illustrated for effecting closure of the rhodium-plated switch contacts, which are rated at 0.5 ampere resistive or inductive at 28 volts direct current or 10-watt lamp load at 115 volts alternating current, and are hermetically sealed to permit safe

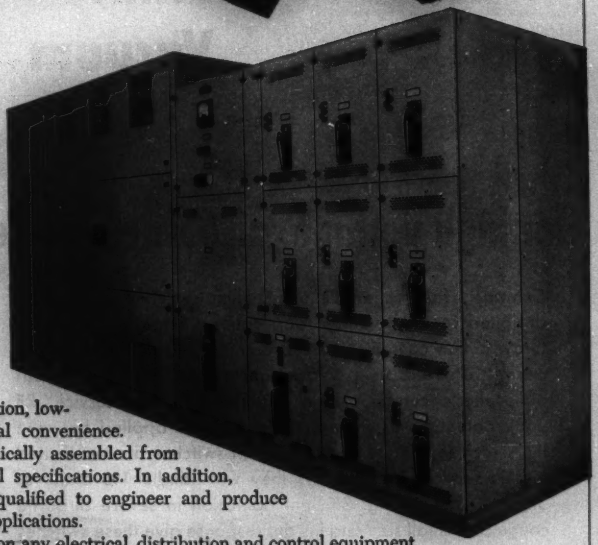
(Continued on page 50A)

IT'S FEDERAL PACIFIC EQUIPMENT FOR GRUMMAN'S NEW JET PLANT



At right, below... one of the 13 Federal Pacific Unit Substations with Federal Pacific Type DMB drawout circuit breakers in the electrical system of the new Peconic River plant... Electrical Contractors, Broadway Maintenance Corp., Long Island City, N. Y. and Charles A. Mulligan, Inc., Central Islip, N. Y.... Electrical Engineers, Guy B. Panero, New York City.

GRUMMAN AIRCRAFT ENGINEERING CORP., Bethpage, Long Island, N. Y., has recently occupied the Navy's new Peconic River plant designed for the assembly of the sweptwing, F9F-8 Cougar jet fighters. Modern to the last detail, the plant's distribution and control equipment for electric light and power is Federal Pacific throughout and includes 13 Unit Substations, 1500 feet of Plug-In Bus Duct, many Distribution Light and Power Panels, and a wide variety of miscellaneous devices.



Federal Pacific equipment is in a class by itself for ease of installation, low-cost maintenance, and operational convenience. Much of it is quickly and economically assembled from standard units to meet individual specifications. In addition, Federal Pacific is exceptionally qualified to engineer and produce equipment required for special applications.

Write for descriptive literature on any electrical distribution and control equipment in which you are interested through the whole range from 110 to 300,000 volts... and submit any particular problems to us for study and recommendations.

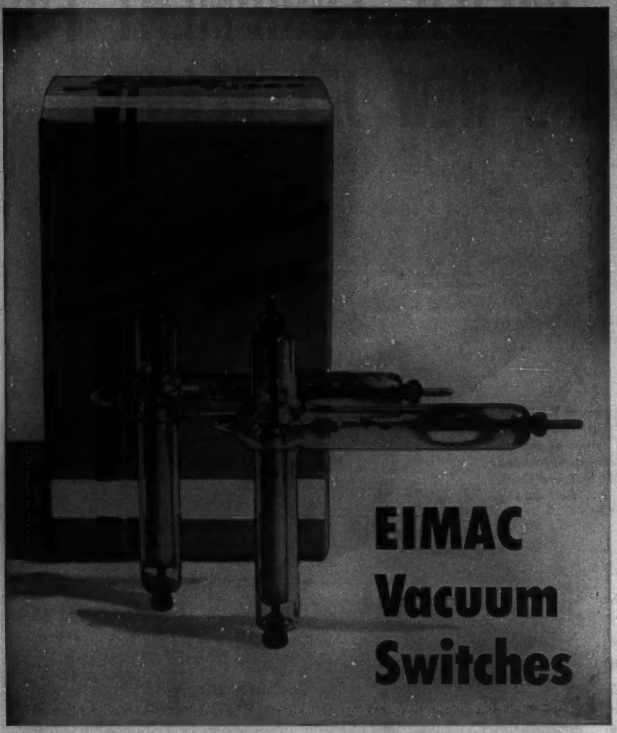
Federal NOARK

FEDERAL PACIFIC ELECTRIC CO.

FORMERLY — FEDERAL ELECTRIC PRODUCTS COMPANY AND PACIFIC ELECTRIC MANUFACTURING CORP.

Main Office: 50 PARIS STREET, NEWARK 1, N. J.

Federal Pacific products: Stab-lok Circuit Breakers, Motor Controls, Safety Switches, Service Equipment, Industrial Circuit Breakers, Panelboards, Switchboards, Control Centers, Bus Duct, High voltage circuit breakers and power switches ★ Sales offices in principal cities.



for high voltage, airborne service

Compact, fast action Eimac vacuum switches are custom designed for high voltage application. Single pole, double throw action contacts are precision spaced in high vacuum, permitting reliable performance regardless of ambient atmospheric conditions. In antenna switching service, RF peak potentials as high as 20kv may be applied between the switch terminals. Eimac vacuum switches are not limited to this service, however, as they will handle 1.5 amps at 5kv in DC switching. Efficient operation in severe airborne conditions, small size and instant response give these switches a distinct advantage over conventional relays. Now available are four Eimac switch types, including one for pulse service.

For further information contact our Application Engineering department

Eimac

EITEL-McCULLOUGH, INC.
SAN BRUNO, CALIFORNIA
The World's Largest Manufacturer of Transmitting Tubes

(*Continued from page 48A*)

operation even in explosive atmospheres. Calibration data, temperature, life, and vibration characteristics, and installation information are included in the booklet.

Instrument Transformer Buyer's Guide The 1955 edition of the General Electric Instrument Transformer Buyer's Guide, containing information on the complete General Electric line, has been announced as available from the company, at Schenectady 5, N. Y. The illustrated 100-page publication, designated *GEC-1028*, contains ratings, American Standards Association accuracy classifications, and prices of all standard General Electric indoor and outdoor potential and current transformers. Listings of ratio and phase-angle tests, tables of replacement types, and mechanical and thermal data are included.

Booklet on Shaped Wire. A 16-page illustrated booklet *DH-1226* describing ways of reducing machining costs with Page shaped wire has been issued by the Page Steel and Wire Division of American Chain and Cable Company, Monessen, Pa. Included in this publication are figures for calculating areas and weights of common shapes, physical properties charts, millimeter and hardness conversion tables, standard wire gauges, and stock lists of carbon steels and stainless steels.

Standardized Gearing Manual. Foote Brothers Gear and Machine Corporation has released a new engineering manual on their line of duty-rated lifetime gearing. All available standard gear sets are listed by center distance and capacity, to give complete and convenient selection. The book also contains material helpful in the selection of proper gear sets. Efficient, space-saving gear arrangements are shown and a section is devoted to gear maintenance tips. Write to Foote Brothers Gear and Machine Corporation, 4545 South Western Boulevard, Chicago 9, Ill. Ask for Engineering Manual *DR Number 2*.

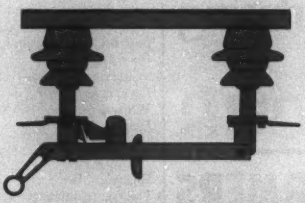
Ceramics Bulletin. A new bulletin, number *551*, which supplies the latest information on the mechanical and electrical properties of AlSiMag technical ceramics has just been published by American Lava Corporation, Chattanooga 5, Tenn. Copies are available, free of charge, from the manufacturer.

Bulletin on Metal-Clad Switchgear. Metal-clad switchgear rated 2.4 kv to 13.8 kv, and 50 to 500 megavolt-amperes, is described comprehensively in General Electric Bulletin *GEA-5664C*. This 4-color 52-page publication includes detailed discussion of applications, installation, maintenance, advanced design features, accessories, etc. Of special interest are tables of dimensions and weights, foundation data, and guide form specifications for many applications. Requests for the

(*Continued on page 54A*)

PROBLEMS

FEEDERS

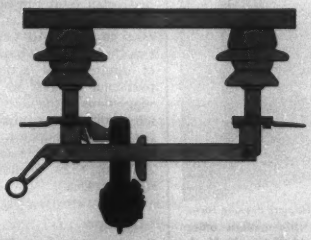


S&C CONVERTIBLE DISCONNECT

plus

INTERRUPTING UNIT

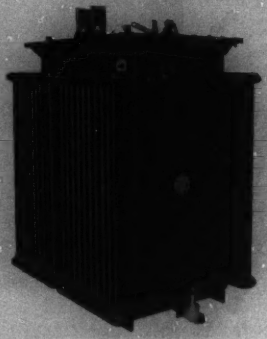
Equal



S&C LOAD INTERRUPTER

more and more

engineers of leading industries are specifying



250 KVA, Oil Immersed, Self-Cooled Distribution Transformer, Type LS.

Marcus TRANSFORMERS

for trouble-free operation and performance beyond specifications

A COMPLETE LINE OF OIL IMMERSED, ASKAREL, AND DRY TYPE TRANSFORMERS up to 5000 KVA

- POWER
- DISTRIBUTION
- UNIT SUBSTATION
- GENERAL PURPOSE
- PHASE CHANGING
- ELECTRIC FURNACE
- RECTIFIER
- WELDING
- MOTOR STARTING
- SPECIAL

Marcus Transformers installed for lighting distribution in new Ford plants near San Jose, California, Louisville, Kentucky, and Mahwah, New Jersey as part of the Ford Motor Company's huge coast-to-coast multimillion dollar expansion program.

Architects
Albert Kahn Associates — Giffels & Vallet and L. Rosseti

Electrical Contractors
Fischbach and Moore, Inc.—San Jose, Calif.
Hatfield Electric Company—Louisville, Ky.
A. Neri, Inc.—Mahwah, New Jersey

Courtesy Newark Evening News

South front of beautiful, ultra-modern office section of new Ford plant at Mahwah, N. J.

"Mark of Quality"

MARCUS MTC

Representatives in Principal Cities

Marcus TRANSFORMER CO., INC.
RAHWAY, NEW JERSEY

(*Continued from page 50A*)

bulletin should be addressed to General Electric Company, Schenectady 5, N. Y.

Side Indicator Panel Meters. An engineering data sheet published by International Instruments, Inc., describes a new series of large side indicator panel meters. The meters save space and improve readability through the use of a bilevel scale. These new model *1145* meters require a panel area of only 5.5 square inches. For a copy of the new data sheet, write to: International Instruments, Inc., Post Office Box 2954, New Haven 15, Conn.

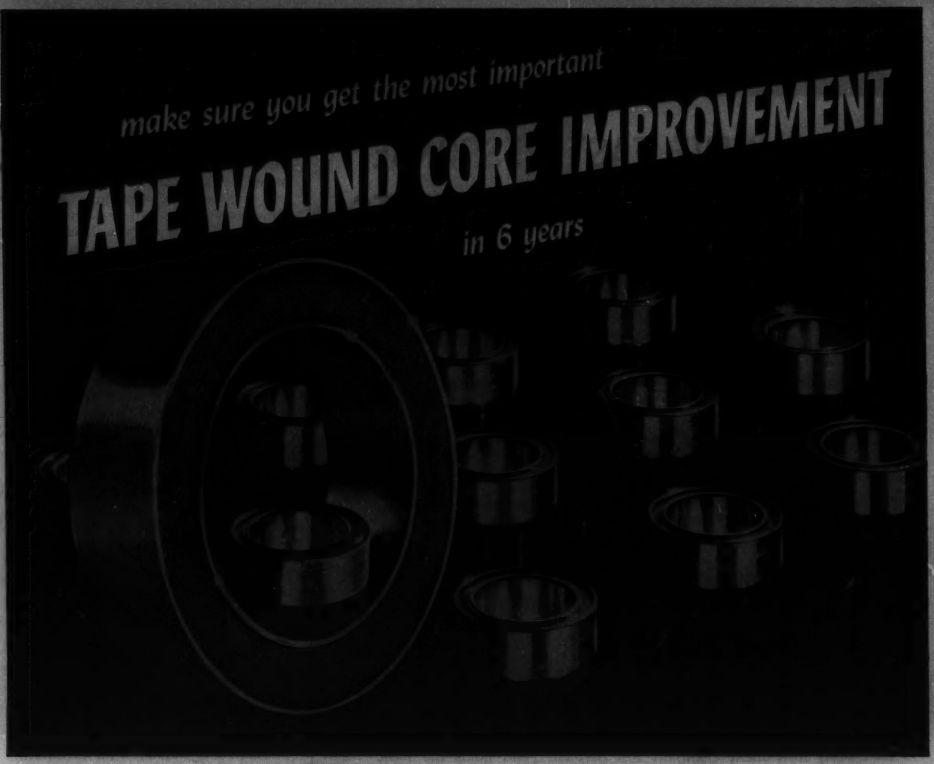
White-Rodgers Controls. A 32-page catalogue describing White-Rodgers automatic controls for heating, refrigeration, and air conditioning has been released. The catalogue contains information on room thermostats, space thermostats, relays, pressure, and hydraulic-action temperature controls. Copies of the catalogue are available from any White-Rodgers wholesaler, branch office, or by writing directly to White-Rodgers Electric Company, St. Louis 6, Mo.

Electric Indicator Motors Brochure. Electric Indicator Company, Inc., has released a brochure and handbook, available without obligation to engineers, purchasing agents, and others in the field. The 24-page brochure describes over 125 hysteresis and salient-pole induction synchronous motors. Performance curves and characteristics are given. Full data are also included for polarized and stabilized units, as well as for new Elinco subfractional motor-generator sets. The brochure, *EI-4A*, is bound in convenient file form and may be obtained upon request from Electric Indicator Company, Inc., Springdale, Conn.

Du Pont Booklet. Helpful tips on ways to apply economical and efficient air conditioning to different types of building, ranging from homes to manufacturing plants and retail establishments, are outlined in a new Du Pont booklet. Entitled, "Guideposts to Better Air Conditioning Installations," the 36-page booklet is a compilation of semitechnical articles. A section of particular interest to architects contains suggestions on the most practical location of air-conditioning equipment from a building design standpoint. Copies of booklet *A-8726* are available on request from F. R. Zumbro, 6529 Nemours Building, Wilmington, Del.

Brazing Manual. The Air Reduction Sales Company has announced the availability of a 24-page brazing manual. This manual is concerned with the application of the major brazing methods in joining metals using silver alloys and filler metals, fluxes, and gas atmospheres. Over 20 tables, drawings, and photographs are

(*Continued on page 56A*)



revolutionary ALUMINUM CORE BOX† *construction*

withstands HIGH TEMPERATURE • VACUUM IMPREGNATION
HEAVY WINDING STRESSES • SHOCK and VIBRATION

This is a development which calls for immediate changes in purchasing specifications for Tape Wound Cores, because introduction of the Aluminum Core Box means designing your toroids around four important new advantages:

1. Use of an aluminum core box means the new Magnetics, Inc. tape wound cores will withstand temperatures of *at least* 450° F.
2. Because of the unusual seal provided by forming the aluminum over the silicone glass seal, true vacuum impregnation of your coils is now possible. Varnish cannot penetrate the core box and affect magnetic properties of the tape.
3. The strong aluminum construction absolutely prevents deflection of the core box when coils are wound—a distortion-free construction which means no change of magnetic properties.
4. Cushioned with an inert material, the tape winding in the core box is protected against vibration and shock. In most cases it is so completely minimized that it is no longer a problem.

Because of the many advantages of these new Magnetics, Inc. Tape Wound Cores, it will pay you many times over to specify "Aluminum Core Boxes" on your next order.

†PATENT PENDING

Immediately available in 109 standard sizes, using all commercially available magnetic materials.

ALL *Performance-Guaranteed*

For full details, write for
Bulletin TWC-200
Catalog TWC-100

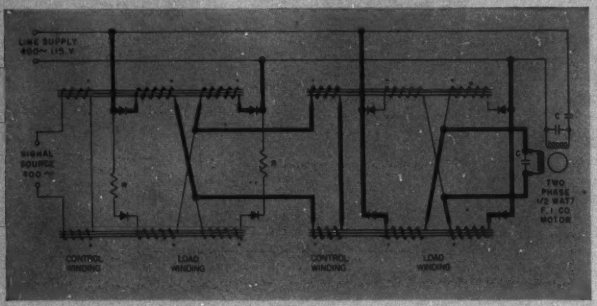
MAGNETICS inc.

DEPT. EN-21, BUTLER, PENNSYLVANIA

SINCE 1915 LEADERS IN AUTOMATIC CONTROL

HALF-WAVE FAST RESPONSE MAGNETIC AMPLIFIER CIRCUITS

An important requisite of any practical amplifier is that it should be possible to cascade several units if more amplification is required than a single stage can offer. In usual magnetic amplifiers, this creates some practical difficulties because the inherently long time constants of each stage add up, and the cumulative time constant of the several stages may become excessive for practical applications.



Ford Instrument Company has perfected and holds the basic patents on circuits which allow cascading magnetic amplifiers with stages operating on successive half-cycles of the a-c supply.

In the circuit shown here, amplification in each stage of the amplifier is accomplished by pre-setting the core fluxes with the control-winding signal during one half-cycle of the applied load-winding voltage. During the next half-cycle, when the load-winding conducts, the control winding contribution is negligible. In this mode of operation the control winding of each stage of the amplifier receives its signal during the reset or non-conducting half-cycle of that stage of amplification. The effect of this signal occurs during the next half-cycle, thus the time constant in the stage is at a minimum of ½ cycle.

The amplifier uses half as many elements (cores and rectifiers) as the conventional bridge (full-wave circuit), and has a constantly higher figure of merit (power gain per cycle of time constant).

In amplification problems it will pay you to talk to the engineers of Ford Instrument Company. For forty years this company has specialized in designing and manufacturing special computers and controls. Send your problem to Ford.

57

FORD INSTRUMENT COMPANY
DIVISION OF THE SPERRY CORPORATION
31-10 Thomson Avenue, Long Island City 1, N.Y.

ENGINEERS
of unusual abilities can find a future at FORD INSTRUMENT COMPANY. Write for information.

(*Continued from page 54A*)

reproduced in this booklet. For a copy of the new "Brazing Manual," write to: Air Reduction Sales Company, 60 East 42d Street, New York 17, N. Y.

Military Specifications for Shock Requirements. A summary of shock and vibration requirements of military specifications has been compiled by Barry Controls Incorporated of Watertown, Mass., manufacturers of shock and vibration isolation equipment. Available in bulletin form, the summary sheets were designed to provide a quick reference sheet for electronics and aviation design engineers who are concerned with shock and vibration. Each of the military specifications is listed with the specific vibration and shock requirements summarized. Copies of this bulletin, Barry bulletin *804A*, may be obtained by writing Barry Controls Incorporated, 1000 Pleasant Street, Watertown, Mass.

Thermocouple and Pyrometer Bulletin. A new edition of their 56-page bulletin *P1238* on thermocouples and pyrometer accessories has been published by The Bristol Company. The bulletin, a buyer's guide and user's manual, contains engineering data on thermocouples, wells, head assemblies, and other pyrometer accessories. Illustrated, this publication contains suggested installation techniques, as well as thermocouple calibration tables. Copies are available on request from The Bristol Company, Waterbury 20, Conn.

Lighting Leaflet. A leaflet giving information for the installation and operation of fluorescent lamps with Luxtrol light controls, has been issued by The Superior Electric Company, Bristol, Conn. The 4-page booklet shows a complete wiring diagram and explains the type of ballasts, sockets, and switches used. Superior Electric's Luxtrol light control type *WBD360* unit enables home owners to vary light intensity to any degree, from complete darkness to full brightness, at the turn of a dial. This unit formerly controlled only by incandescent lamps now operates equally well with fluorescent lighting.

Motors Bulletin. The Holtzer-Cabot Motor Division, National Pneumatic Company, has released a catalogue on its special motors, motor-generator sets, and related products. The data include the complete range of frame sizes—from d-c servo motors of 1⅛-inch diameter to power motors of 7-inch diameter. For copies of bulletin *MO3.3* write to Holtzer-Cabot Motor Division, National Pneumatic Company, Inc., 125 Amory Street, Boston 19, Mass.

High-Current Test Units. A set of data sheets describing Multi-Amp portable high-current test units for safely checking and calibrating electrically actuated protective devices, is now available from Multi-Amp Corporation. These bulletins contain up-to-date information on the recommended uses, electrical ratings, component equip-

(*Continued on page 60A*)

THE NEW IMPROVED TIREX CORD

Bends and twists without breaking or kinking!

IT'S CURED IN LEAD: the smooth, dense jacket stands abrasion and wear.

Its exclusive SELENIUM NEOPRENE ARMOR makes it tough as a tire!

It is the only portable cord that has passed for 35 years these tests of cord endurance: *Abrasion, Abuse, Heat, Stress* and *Water.*

NOW! **After extensive research and development, based on country-wide customer surveys and field tests, *the New TIREX Cord is Better than Ever!***

Let us send you Folder 1022 about the new, improved TIREX. Write today to the address below.

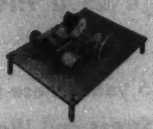
Simplex TIREX

SIMPLEX WIRE & CABLE CO. **79 Sidney Street, Cambridge 39, Massachusetts**

What's Your Angle?

says she . . . WHAT ANGLE? says he . . . EVERYONE'S GOT AN ANGLE . . . says she . . . and SERVO HAS DEVELOPED A LINE OF EQUIPMENT TO MEET YOUR NEEDS NO MATTER WHAT YOUR ANGLE!

IF IT'S YOUR PHASE ANGLES that need analyzing, the SERVOSCOPE* will accurately and rapidly measure them. Just a few turns of the dial will give you the values for plotting magnitude and phase curves. The SERVOSCOPE generates modulated carrier, low frequency sine, and square waves. So, whether you're developing new designs or de-bugging production testing, let SERVOSCOPE, the only equipment of its kind, save you man-hours and prevent costly errors. *T.M.



IF IT'S DESIGN ANGLES — the SERVOBOARD* provides a flexible experimental electro-mechanical assembly that allows you to mock-up your intended designs and test them. No longer must you wait for an overloaded breadboard shop to come through. Developed as an aid to the design of servo-mechanisms and computers, the SERVOBOARD will quickly provide the standard precision parts needed to set a preliminary design into mechanical form.

IF IT'S AZIMUTH ANGLES for direction finding, SERVO's VHF Receiver will do the job. Its directly calibrated 72° bandspread dial speedily locates the frequency region of interest. This precision constructed receiver provides all custom features needed for communication and laborntory work. In addition, special outputs are provided for the receiver to be used as a component in complete communication, telemetering or direction finding systems.

SERVO's PRECISION CONSTRUCTED EQUIPMENT IS AN EXAMPLE OF SOUND ENGINEERING AND UNEXCELLED CRAFTSMANSHIP. BEHIND SERVO PRODUCTS STANDS A RECORD OF OUTSTANDING PRACTICAL ENGINEERING ACHIEVEMENTS.

SERVO CORPORATION of AMERICA

New Hyde Park
Long Island, N.Y.

FOR FURTHER INFORMATION WRITE

SERVO CORPORATION OF AMERICA
New Hyde Park, N. Y.

Please send further information and details on the following:

☐ SERVOSCOPE ☐ SERVOBOARD ☐ VHF RECEIVER

Name_____

Title_____

Company name_____

Address_____

City_____ Zone____ State_____

EG6

(*Continued from page 56A*)

ment, and physical dimensions of the units. These data sheets, series number *55*, may be obtained, without charge, from Multi-Amp Corporation, 10 Third Street Newark, N. J.

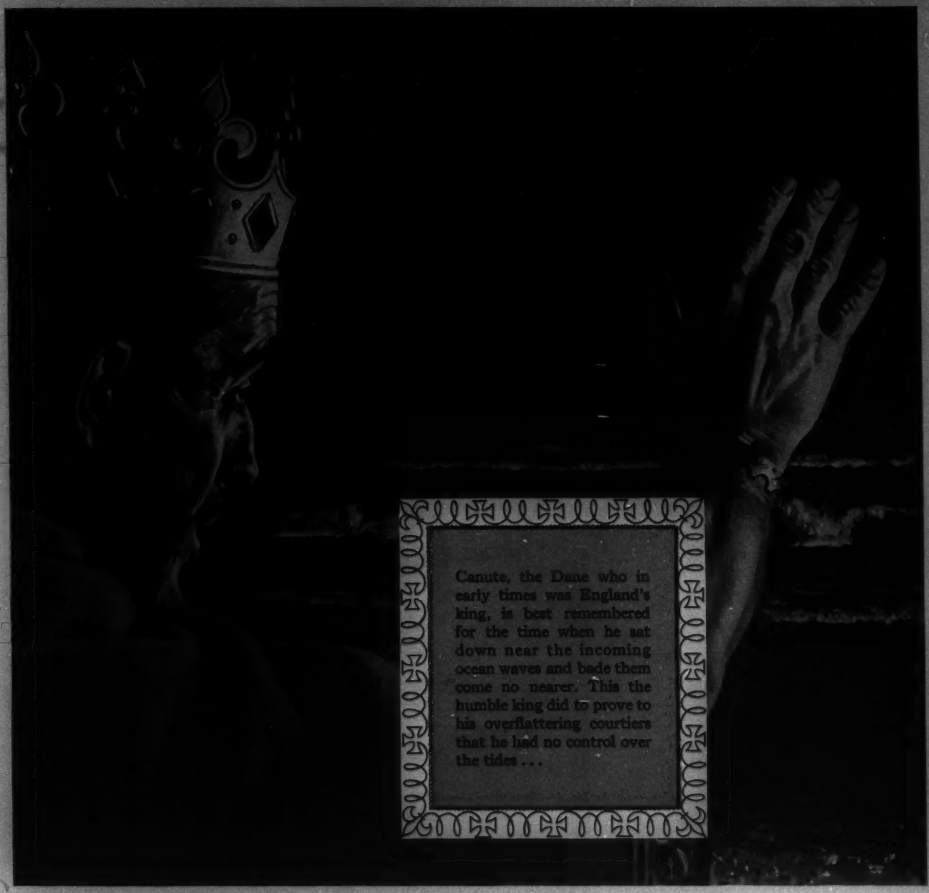
Tube Catalogue. Data on Superior's cathode and other vacuum-tube components are found in a catalogue published by Superior Tube Company, Norristown, Pa. This 20-page publication, "Superior Tube Electronic Products," illustrates and describes their line of products. The section on cathodes tabulates the dimensions and tolerances for the company's standard round and shaped cathodes in both seamless and Lockseam forms. The final three pages describe Superior's mill procedures and quality control. Copies of the catalogue, designated as number *501517*, may be obtained by writing to Superior Tube Company, Germantown Avenue, Norristown, Pa.

Ceiling Diffusers. A 28-page catalogue, *F 6597*, containing information on Uni-Flo square and rectangular ceiling diffusers, Line-O-Flo ceiling diffusers, and square and rectangular ceiling returns, is now available. The new catalogue includes dimensional drawings, ordering information, typical installation methods, and accurate performance data. For a copy of this informative catalogue, write to Barber-Colman Company, Department 766, Rockford, Ill., and request catalogue *F 6597*.

American Standards. A list of American Standards, 1955 edition, has been published. The 48-page publication lists and indexes about 1,500 American Standards. There are 210 for construction and civil engineering, 153 mechanical, 272 electrical, 158 safety, 165 textiles and wearing apparel, 251 photography and motion pictures, 74 petroleum products, 69 chemical, 62 metallurgy, 38 gas-burning appliances, 32 drawings, letter symbols, and abbreviations, 18 mining, 11 rubber, 10 office equipment and supplies, and a miscellany of others. Free copies are available on request from the American Standards Association, 70 East 45th Street, New York 17, N. Y.

Electronic Metal Detector Bulletin. A description of what the Allis-Chalmers electronic metal detector is, and what it does, is given in a new bulletin released by the company. Used to inspect plastics, food, confectionery, tobacco, paper, rubber, textiles, medicines, explosives, glass, ceramics, leather, and wood; the metal detector helps to maintain product purity and prevent damage to equipment. The bulletin also tells how the detector is built, and how it works to provide positive electronic inspection. Copies of "Allis-Chalmers Electronic Metal Detector," *15B7217B*, are available on request from Allis-Chalmers Manufacturing Company, 931 South 70th Street, Milwaukee, Wis.

(*Continued on page 62A*)


Canute, the Dane who in early times was England's king, is best remembered for the time when he sat down near the incoming ocean waves and bade them come no nearer. This the humble king did to prove to his overflattering courtiers that he had no control over the tides . . .

STEMMING THE OCEAN TIDE

As King Canute nobly showed, no man, even in exalted position, can govern the elements . . . our efforts only can be toward resisting them. Kerite Cable, in submarine, underground and above-ground applications, has proved, over the years, singularly successful in resisting the destructive action of the elements —even of time itself. Small wonder the dependability, durability and unique superiority of Kerite Cable insulation have been relied on for years, the world over, wherever formidable cable problems present themselves.

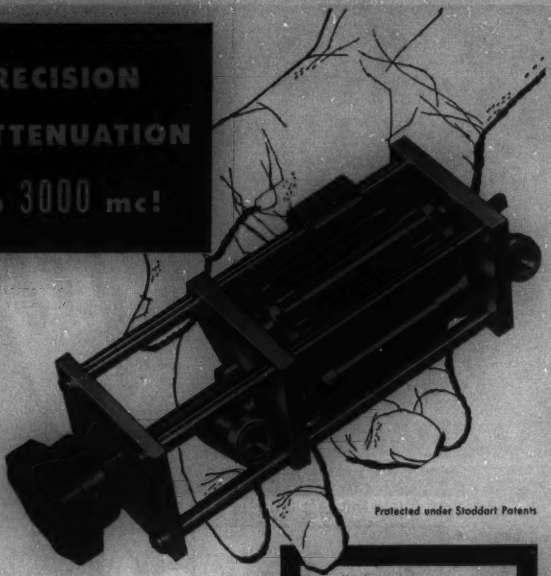
The value and service life of a product can be no greater than the integrity and craftsmanship of its maker.

Founded 1854

KERITE CABLE

THE KERITE COMPANY—30 Church St., New York 7, N. Y.
Offices also at 122 S. Michigan Ave., Chicago; 582 Market St., San Francisco;
3901 San Fernando Rd., Glendale 4, Calif.; 31 St. James Ave., Boston

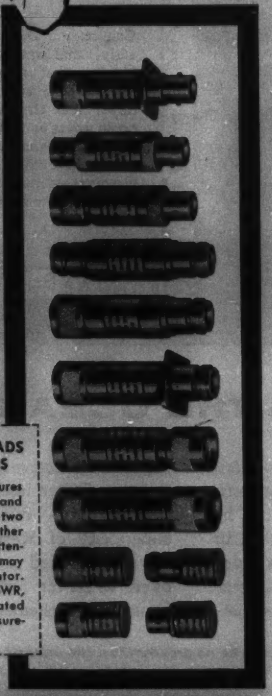
PRECISION ATTENUATION to 3000 mc!



Protected under Stoddart Patents

six-position
TURRET ATTENUATOR
featuring **PULL-TURN-PUSH** *action*

FREQUENCY RANGE: dc to 3000 mc.
CHARACTERISTIC IMPEDANCE: 50 ohms.
CONNECTORS: Type "N" Coaxial female fittings each end.
AVAILABLE ATTENUATION: Any value from 1 db to 60 db.
VSWR: 1.2 max., dc to 3000 mc/s, values from 10 to 60 db. As value decreases below 10 db, VSWR increases to not over 1.5.
ACCURACY: ± 0.5 db.
POWER RATING: One watt sine wave power dissipation.



SINGLE "IN-THE-LINE" ATTENUATOR PADS and 50 ohm COAXIAL TERMINATIONS

This new group of pads and terminations features the popular Type C and Type N connectors, and permits any conceivable combination of the two styles. For example, the two connector types, either male or female, can be mounted on the same attenuator pad, with or without flanges, so that it may serve as an adapter as well as an attenuator. Frequency range, impedance, attenuation, VSWR, accuracy and power rating are as designated above. Send for free bulletin entitled "Measurement of RF Attenuation."

STODDART AIRCRAFT RADIO Co., Inc.
6644-B Santa Monica Blvd., Hollywood 38, California · Hollywood 4-9294

(Continued from page 60A)

Single-Phase Oil-Filled Transformers. A new bulletin describing the single-phase oil-filled transformers of The Standard Transformer Company, Warren, Ohio, is now available. The bulletin gives shipping weights and dimensions, connection diagrams, and National Electrical Manufacturers Association ratings. Components and transformers are illustrated. Ask for Standard bulletin *S-401-B*.

Contactor and Control Relay Bulletin. Allis-Chalmers heavy-duty d-c contactors, including the new type *522* units and control relays for steel mill and similar heavy-industry applications, are described in a new bulletin. A feature of the line, available in ratings of from 25 to 100 amperes, 600 volts maximum, in single- and double-pole units with either normally open or normally closed contacts and mechanical interlocks, is the high degree of parts interchangeability which permits considerable reduction in spare-parts inventories. This is illustrated by a chart with color code. Copies of the bulletin, "Heavy Duty D-C Contactors and Control Relays," *14B8171A*, are available on request from Allis-Chalmers Manufacturing Company, 931 South 70th Street, Milwaukee, Wis.

New Circuit Breaker Catalogue. The I-T-E Speedfax Catalog, now available, has been designed to provide all essential information on the selection and application of molded-case and large air circuit breakers. Application sections make extensive use of charts and tables to explain the proper selection of circuit breakers for motor circuits, bus duct, conductors, and transformer secondary applications. Illustrated descriptive sections provide a pictorial explanation of the many advantages that the use of circuit breakers provide. Also included in the 60-page catalogue are the latest circuit breaker prices, dimensions, and ordering instructions, arranged and indexed to reduce reference time and eliminate errors. It is available from the I-T-E Circuit Breaker Company, 1924 Hamilton Street, Philadelphia 30, Pa.

Wire and Cable. A new booklet, "Wire and Cable for the Pulp and Paper Industry," has been announced by the General Electric Company. Edited for the electrical engineers who design the electric distribution systems for these industries and for the men who are responsible for the maintenance of these systems, the booklet covers power distribution for15-kv circuits, 4.16- and 2.4-kv circuits, and 600-volt circuits. Cables for control circuits subjected to specific corrosive chemical atmospheres are also discussed. A comprehensive listing showing types of cables suitable for ducts and conduit, aerial and rack installations in areas that handle bleaching, acid-making, causticizing, evaporators, digesters, and many other specific mill operations are included in the book. This publication, No. *19-224*, is available without charge from the General Electric Construction Materials Division, Bridgeport 2, Conn.